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CHP in NYC: A Viability Assessment

This report represents the culmination of work begun by a team of graduate students participating in the Urban Energy Workshop sponsored by the *Center for Energy, Marine Transportation and Public Policy* at Columbia University's School of International and Public Affairs. As part of this workshop, the team conducts research on a topic of interest to stakeholders interested in urban-scale energy issues.

The topic for this report was selected in consultation with the Energy Department at the New York City Economic Development Corporation (EDC), the unit that serves at the principal energy policy advisor to Mayor Michael Bloomberg. Although this report was prepared for the benefit of EDC, it is not an official agency publication and as a result does not necessarily represent the views of the City of New York.

In carrying out this research, the team received assistance from Craig Wilson, Senior Project Manager at EDC, along with a lengthy list of industry experts and local stakeholders too numerous to name here. We gratefully acknowledge the contribution they made to the drafting of this report.

Despite the tremendous amount of assistance that we received, any omissions or errors in fact are entirely the responsibility of the authors.

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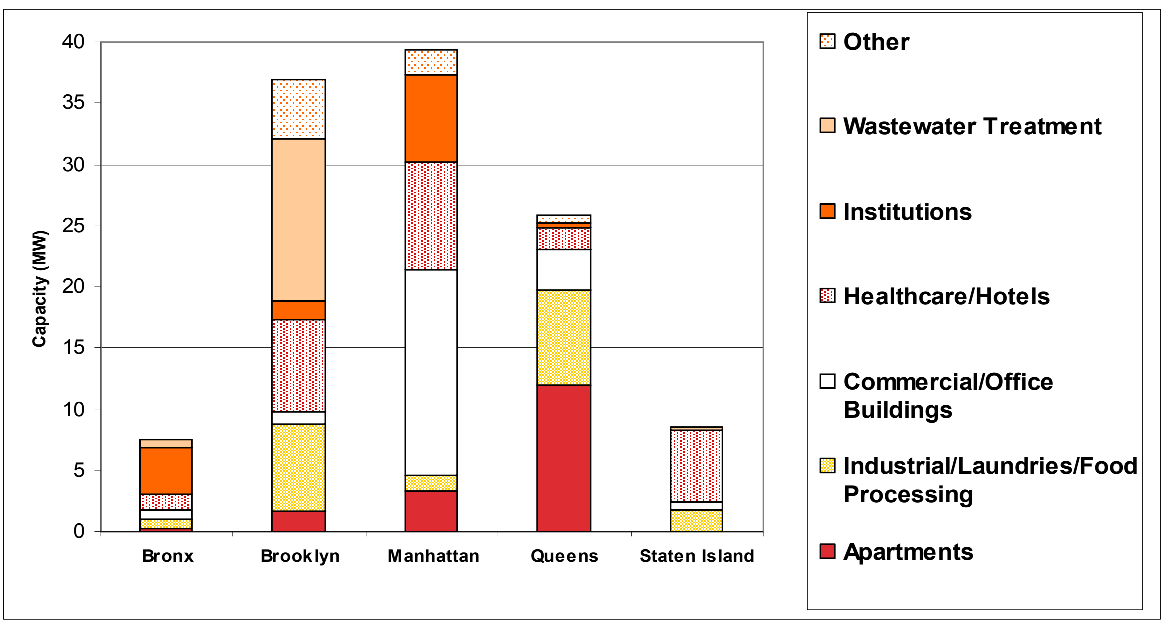
CENTER FOR ENERGY, MARINE TRANSPORTATION AND PUBLIC POLICY

CHP in NYC: A Viability Assessment
Executive Summary

By several different accounts, New York City faces an imminent electricity supply shortfall due to steady demand growth, the anticipated retirement of existing in-city power generation capacity, and difficulty siting and financing large new in-city power plants. *PlaNYC*, the long-term growth and sustainability plan released by New York City Mayor Michael Bloomberg in April 2007, details a variety of approaches the City can pursue to reduce the size of this anticipated supply gap. This analysis, prepared for the benefit of the Energy Department at the New York City Economic Development Corporation (EDC), examines the local viability of one of the technologies cited in *PlaNYC* – the use of small-scale (<10 MW) cogeneration technology, also known as combined heat and power (CHP) systems.

The name refers to the fact that CHP technology simultaneously generates heat and electricity at or near the point where the energy will be consumed. Because of their design, CHP systems are on average more than twice as efficient as conventional, large-scale central station power plants. As a result, CHP technology is potentially a valuable tool in *PlaNYC*'s efforts to reduce local greenhouse gas emissions.

Figure 1. Total Installed Capacity of Small-Scale CHP Systems in New York City (by Application and Borough)



There are a range of CHP technologies currently deployed around New York City in different settings, exploiting both older and cutting-edge system designs. The vast majority of systems are powered by reciprocating engines, a familiar technology available in a wide range of system sizes. Microturbines represent a newer technology that is quickly gaining in popularity, likely attributable to its position as the only CHP technology currently eligible for federal tax credits. Microturbines tend to be smaller in their power generation potential, contributing to a decades-long trend of decreasing average CHP system size around New York City.

Figure 2. New York City CHP Installations and Capacities (1974-2006)

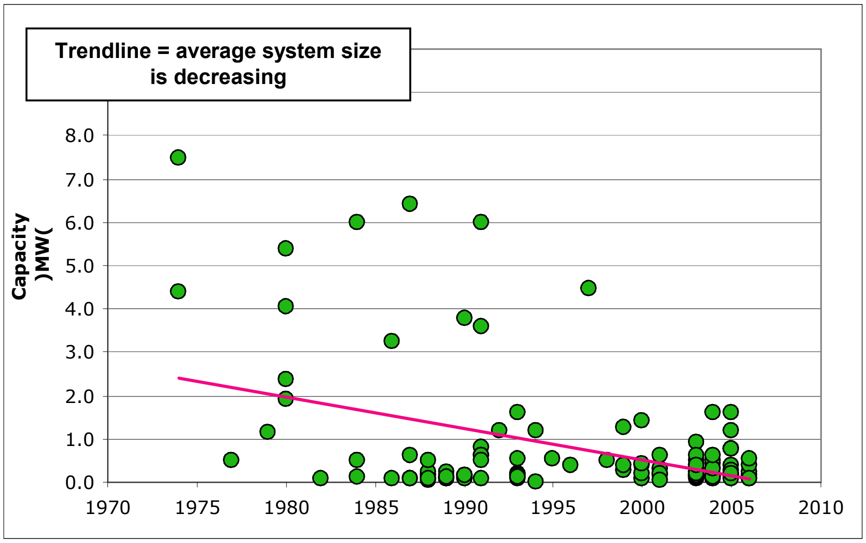
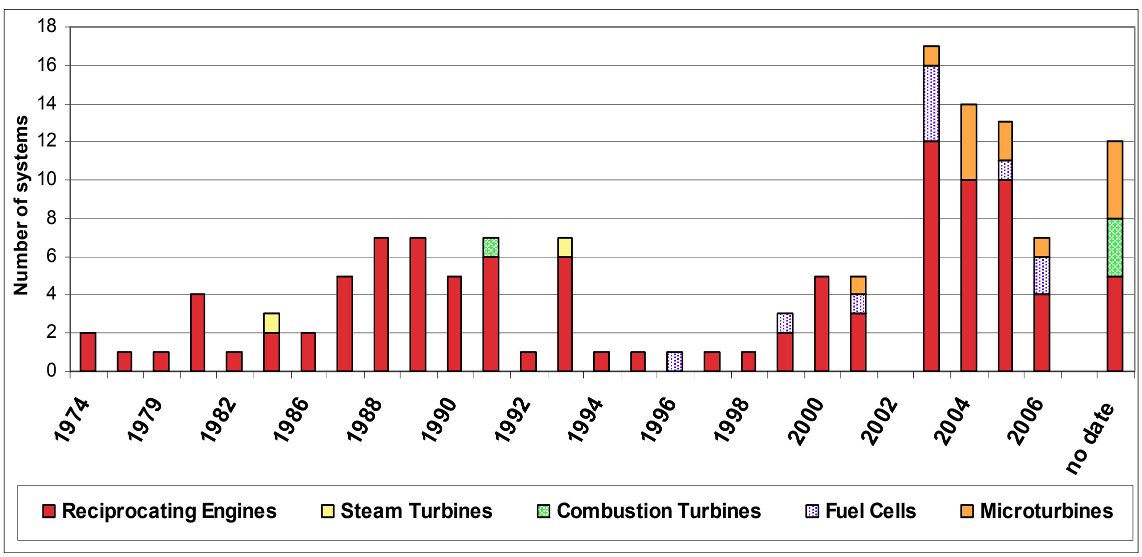


Figure 3. Number of CHP Systems Installed in New York City (by Technology Type) (1974-2006)



A 2002 study by the New York State Energy Research and Development Authority (NYSERDA) forecast significant potential for the deployment of CHP technologies around New York City, totaling nearly 3,200 MW of capacity across various commercial, residential, and industrial sectors. Current deployment lags far below that level, however. Of the 135 local small-scale CHP systems currently installed around the city, we estimate their aggregate capacity at 118 MW, or just 1% of overall local power generation capacity.

There are many factors that influence the current deployment situation, both positively and negatively. Most relevant to the local story are key obstacles that we believe make attainment of *PlaNYC's* deployment target of 800 MW of CHP by 2030 rather challenging. These include:

- **The mechanics of connecting to the Con Edison grid – CHP technology's 'Achilles Heel'**

When a CHP system is linked to the local electric grid, it is said to be 'interconnected' to the grid. When CHP systems operate completely independently of the grid, they are considered to be in 'grid-isolated' or in 'island' mode. Virtually all systems deployed in New York City are interconnected, with the building using the CHP system to generate some portion of its electricity load on-site while deriving the rest of its power from the Con Edison electric grid. This configuration occurs primarily because the price of local real estate makes it too costly to build a CHP system large enough to meet all of a building's energy needs.

The fact that CHP systems must interconnect to the Con Ed grid is potentially problematic because they represent new power sources at locations where the grid was not originally designed to accept them. As a result, the CHP system could send its power out of the building and back into the grid, energizing lines thought to be dead, posing a safety risk to Con Edison repair crews and potentially damaging transformers and other equipment on the line. Con Edison engages in a detailed engineering analysis of each interconnection proposal to determine what – if any – impact it might have at that location on their network. State regulators grant Con Edison the authority to impose technology requirements on the project developer as a pre-condition for approval of the interconnection, generally with all costs borne by the party proposing the installation. This situation is monitored by state regulators to ensure the fairness of these requirements. Some of the stipulations are costly, however, potentially destroying the otherwise favorable economics of a project. In the future, less complex technological solutions such as fault current limiters and other types of power electronics may help overcome this problem, but some of these technologies are still at the early stages of development, and their local viability remains relatively unproven. We believe EDC and NYSERDA should examine the option of providing some mechanism for offsetting the costs associated with these devices as one way of encouraging CHP deployment. Microgrids, which are small independent power distribution systems that are currently being pursued in London and other cities, may also represent an innovative approach to circumventing some or all of the technological problems associated with interconnections.

- **A complex policy environment and approval process**

Federal and state policies have been quite helpful in supporting local CHP deployment, significantly improving the economics of project installations by providing valuable tax credits and direct project subsidies. New York City's own policymaking efforts are increasingly CHP-friendly, although Fire Department (FDNY) concerns over the high pressure gas lines required for microturbine projects have clearly had a chilling effect on the use of this technology around the city. Though a special task force convened by City Hall to address this issue has reportedly made progress in resolving FDNY concerns, final rules have yet to be formally adopted, so it is uncertain what proportion of these projects will eventually obtain approval. Once the task force has finished its work, local stakeholders would benefit from learning how the microturbine issue was ultimately resolved.

Con Edison policies and procedures for interconnections are a more vexing matter, raising issues that go beyond the physical considerations of linking to the grid. In public documents Con Edison sounds broadly supportive of CHP technology, but many complaints have been levied by project developers about the opaque application process they must follow to win Con Edison's approval to interconnect CHP systems. In many ways, New York City is no different than other cities in this regard, as research has uncovered similar complaints about the transparency and predictability of the interconnection application and review process involving other utilities. In *PlaNYC,* the City proposes steps that should address some of these concerns locally. Worth noting, however, is the fact that state regulators monitoring this issue report they field few customer complaints about interconnection issues, and that problems often appear to result from communication failures by both parties. New York State Public Service Commission staff also acknowledge the complex nature of Con Edison's network grid, saying that part of the application review problem may be that it's simply harder to interconnect systems in New York City than in other cities.

For that reason, it is unclear how much of the difficulty faced by local projects is a learning curve problem rather than a fundamental shortcoming in the interconnection review process. As Con Edison engineers and project developers gain experience working with these systems, the process may become more predictable. Depending on how the CHP market matures – either tending towards a large number of small projects that are easier to interconnect, or a lesser number of big projects that are more difficult to interconnect – there may also be increased pressure for reforming the interconnection process. It behooves Con Edison to monitor market trends and ensure that staffing levels are sufficient to keep interconnection projects moving apace.

- **Project Economics – Multiple Challenges to Keeping Project Budgets on Track**

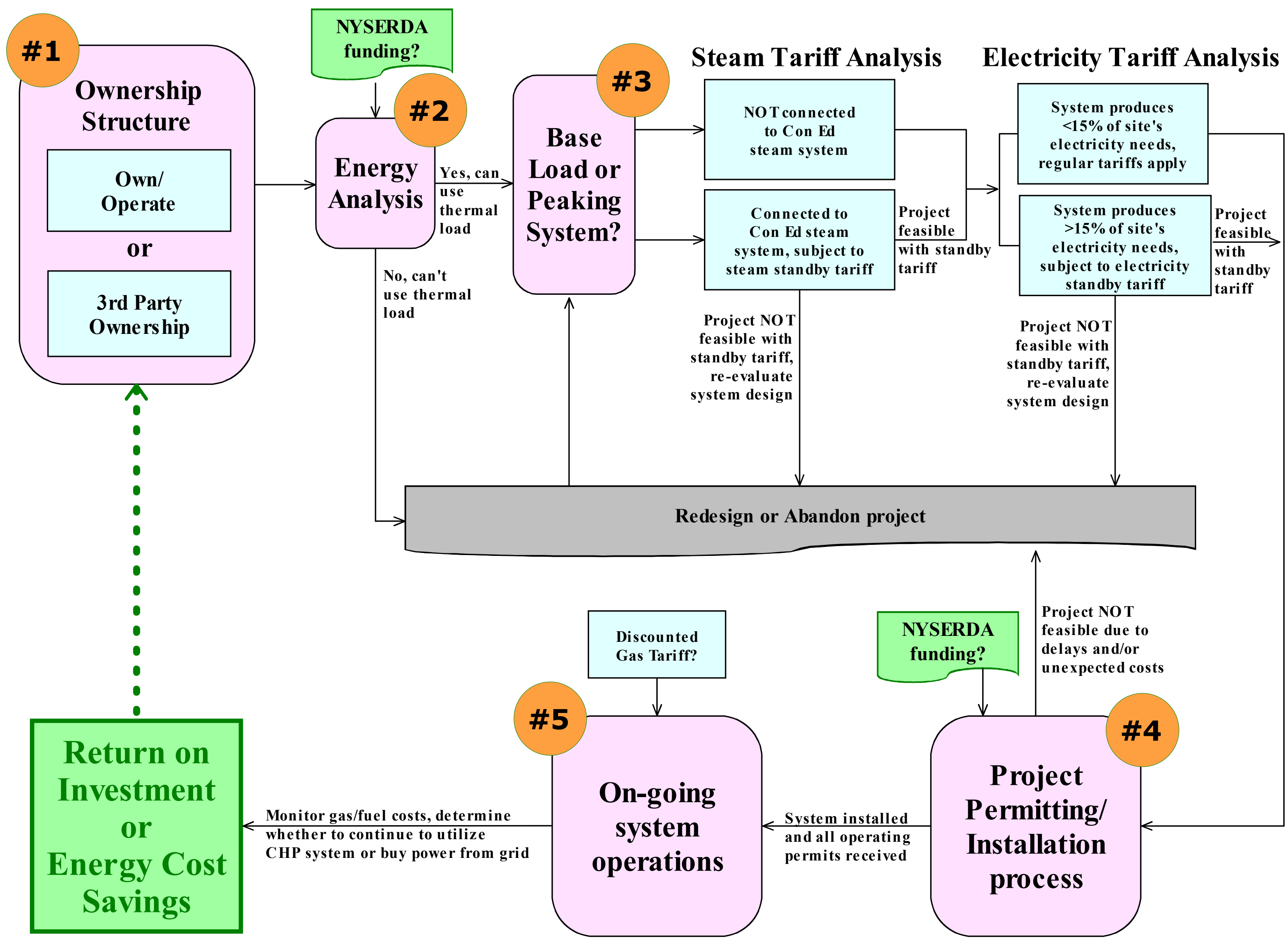
Although facility owners may pursue CHP for several reasons – such as an interest in climate protection or enhanced on-site energy security – at the end of the day, most projects will only be realized if they deliver energy services at a cost equal to or lower than existing grid-based sources. In diagramming the basic decision schema faced by CHP project developers, we have identified five key factors that heavily influence whether projects keep moving forward or run off the rails. [See Figure 4] These include the basic system ownership model, whether there is adequate demand for a system's thermal output, the interaction between utility tariffs and system design, project development costs, and on-going operating costs.

The ownership model is a key starting point, as new market mechanisms known as third-party ownership now put CHP system deployment within the reach of those who previously would have had difficulty affording these systems. System design is another important issue, and must take into account both the thermal and electric demands of the building, in order to ensure the full utilization of the CHP system's heat output. Local tariff structures will further influence the size of the system deployed. Developers must carefully assess whether their CHP system will bump them into an alternative, more expensive tariff class for the balance of their energy needs, potentially destroying the original economic justification for the project.

It is difficult to generalize the development costs for local CHP projects, due to their site-specific nature. The various issues associated with interconnections are often of critical importance in this regard, as Con Edison's technical review may result in additional engineering studies and new componentry not included in the original project budgets. Permitting process delays can also cause projects to lose favorable financing terms. These circumstances collectively add up to a situation where prospective CHP system owners and developers must tread warily when estimating their project budgets, particularly on larger installations, where the perceived risk to the Con Ed system is generally greater. Once a system is operational, it is important to closely monitor fuel costs, as high natural gas prices can at times make CHP more costly than purchasing power from the grid.

In other words, balancing the various economic decisions and uncertainties involved with a CHP project is quite a challenge. Local officials are in a position to help alleviate this situation by providing additional funding for CHP viability assessment studies and focusing advocacy efforts on CHP-friendly tariff structures at the state level.

Figure 4. CHP Economic Decision Schema: Key Factors Affecting the Economic Viability of CHP Projects
Source: Based on original research by Jeanene Mitchell and Stephen Hammer



Conclusion

Combined heat and power technologies can play a significant role in helping New York City address its impending in-city electricity supply shortfall in a more sustainable manner. The growing number of small-scale installations around the city – 40% of which have been deployed in the past five years alone – testify to the value of CHP's greater efficiency and money-saving potential. With the Regional Greenhouse Gas Initiative coming into effect in 2009, bringing with it the prospect of higher electricity prices for grid-based power, CHP may become an even more attractive option for meeting New York City's electric and thermal needs.

Despite the benefits of CHP, there are many opportunities for projects to become sidetracked locally. As this report repeatedly notes, interconnection is a major hurdle, and until it is adequately resolved – through technological solutions, learning-by-doing, or changes in basic market structures, ***PlaNYC*'s goal of 800 MW of CHP by 2030 must be seen as a rather optimistic target**. We advocate a two-track approach, in which the City works with state officials and key market stakeholders to improve both the short and long-term outlook for CHP technologies.

As a first step, we believe that a local 'CHP Partnership' should be established to provide overarching direction and support to any CHP market development effort, operating under the auspices of the City's Economic Development Corporation. This public-private partnership, consisting of local and state government officials, utility representatives, and other key energy sector and environmental/community stakeholders, could harness the knowledge and financial resources necessary to tackle the most pressing issues impeding CHP deployment.

As part of its short-term strategy, the New York City CHP Partnership should focus on evaluating the interconnection guidelines and process currently in place. Policymakers and Con Edison would both benefit from an independent assessment of such issues, as it should clarify the extent to which interconnection difficulties must remain an unavoidable fact of life for local CHP projects. The review should also examine whether Con Edison's fundamental approach towards distributed generation is excessively cautious, or whether it is entirely appropriate given the need to maintain high levels of system reliability.

As a longer term strategy, we believe the Economic Development Corporation and the CHP Partnership should conduct research into new market structures and regulatory systems that more systematically incentivize CHP interconnections with the local grid. The *PlaNYC* report has already announced the Mayor's interest in this subject, and much work must be done to explore how to change the local regulatory schema so it more explicitly rewards Con Edison for facilitating CHP and other distributed generation deployment. Rules promoting microgrid development could also help build demand for CHP technology, as these units would serve as the heart of microgrid energy systems.

As an ever-growing center of global commerce, industry and culture, New York City's burgeoning energy demand shows no sign of abating. While there is a clear role for CHP to play in filling the supply gap, CHP's potential will only be realized to the extent that a pro-CHP policy environment can be implemented within New York City.

Summary of Recommendations

Recommendation #1*: The City of New York should work with Con Edison to examine ways to accelerate the pace of network protector device upgrades on the network. This includes fostering collaboration between Con Edison and various City agencies to ensure that Con Edison receives all necessary permit approvals to carry out this work in a timely manner.*

Recommendation #2*: The City of New York should work with Con Edison and the NYS Public Service Commission to develop more refined maps detailing the extent of the fault current problem within individual network grids. These maps should indicate the different technological options for fault current mitigation available within specific areas, including inverted generation and fault current limiters. This information should then be used in targeted education and outreach efforts promoting CHP deployment among building owners around New York City.*

Recommendation #3*: The New York City Economic Development Corporation should work with NYSERDA and the NYS Public Service Commission to examine whether investments in fault current limiters or power electronics by CHP system developers should be entitled to some type of financial relief from the utility or other entity to help offset the additional cost of these devices.*

Recommendation #4*: The City of New York should work with Con Edison and the NYS Public Service Commission to examine how the 10/20 MW limits for interconnected DG might change if these limits were instead calculated as a percentage of peak demand, as is the practice commonly followed by other utilities. The results of this study should be used to select the method of calculating interconnected DG limits with the greatest potential for increasing levels of CHP deployment in New York City.*

Recommendation #5*: The City of New York should work with the New York City Congressional delegation to advocate for an extension and possible expansion of the federal CHP business tax credit program.*

Recommendation #6*: The NYC Economic Development Corporation and Department of Buildings should establish a mechanism to more systematically educate local developers of large new building projects about NYSERDA CHP-funding opportunities. EDC should also work with NYSERDA to develop funding programs specifically designed to support education and outreach programs targeting the local industrial sector and real estate developers and managers in New York City.*

Recommendation #7*: The New York City Economic Development Corporation should work with NYSERDA and the New York State Department of Environmental Conservation to examine current emissions regulations to determine how the review process can more accurately account for the emissions benefits delivered by CHP.*

Recommendation #8*: Once the Cogeneration Task Force has completed its work in resolving FDNY safety concerns with microturbines, the NYC Economic Development Corporation should collaborate with the NYC Department of Buildings to host a workshop educating building owners/managers and other key stakeholders on how the issue was resolved. This information should also be posted on the EDC website.*

Recommendation #9*: The NYC Economic Development Corporation should seek the collaboration of a range of key local stakeholders in developing the specifications for an on-line portal tracking the status of CHP interconnection applications at Con Edison.*

Recommendation #10*: The NYC Economic Development Corporation should fund the development of a "DG Ombudsman" position responsible for helping to resolve CHP system installation problems in New York City.*

Recommendation #11: *The NYC Economic Development Corporation should meet with Con Edison to discuss their interconnection review staffing plans to ensure the utility is taking all steps necessary to support a potentially dramatic increase in interconnection applications.*

Recommendation #12*: If the City receives approval to establish its own independent financing mechanism for local energy projects, the New York City Economic Development Corporation should allocate a portion of the funds to supplement existing NYSERDA monies available for CHP viability assessment studies.*

Recommendation #13*: The NYC Economic Development Corporation should work with the Public Service Commission to examine the extent to which standby tariffs penalize CHP operations in New York City. As part of this analysis the City and State can examine ways to enhance the use of natural gas tariffs as an incentive for expanding CHP system use around the city.*

Table of Contents

Figures

Boxes

Tables

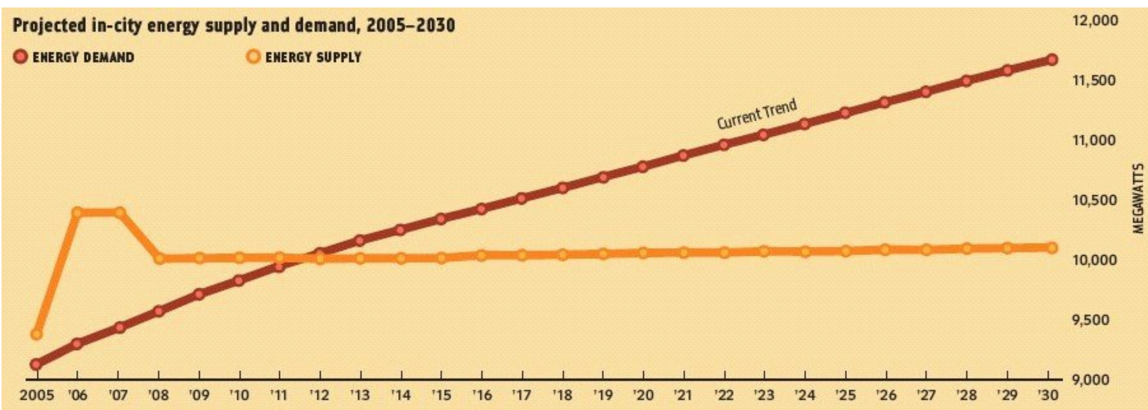
Section 1: Introduction

Overview

Over the past seven years, a series of reports issued by local and statewide organizations have warned that New York City faces an imminent electricity shortfall.[1] The shortfall reflects the combined effects of steady demand growth, the anticipated retirement of existing in-city power generation capacity, and the current regulatory and financing environment. The latter makes it difficult to site or build new generation capacity in the city, or new transmission lines that can import power to New York City.

In 2003 New York City Mayor Michael Bloomberg convened a panel of key stakeholders to examine this issue. Their 2004 Task Force report – *An Electricity Resource Roadmap* – estimated that New York City required approximately 2,600 MW of net new in-city electricity resources by 2008.[2] According to the New York City Office of Long Term Planning and Sustainability, the risk of an imminent power shortfall has abated somewhat; nevertheless, the longer-term picture still appears grim.[3] As indicated in Figure 1, the city will begin falling short of its mandated in-city energy supply requirement beginning in 2012, with the shortfall reaching several hundred megawatts just a few years later.[4, 5]

Figure 1
New York City Projected In-City Electricity Demand and Supply (2005-2030)[6]



[1] For example, see the New York Building Congress Energy Committee. *A Matter of Urgency: New York City's Electric Supply Needs*, 2001; NYISO. *Power Alert: New York's Energy Crossroads*, 2001.
[2] New York City Energy Policy Task Force. *New York City Energy Policy: An Electricity Resource Roadmap*. January 2004.
[3] City of New York. *PlaNYC: A Greener, Greater New York*. Office of Long Term Planning and Sustainability, New York City Office of Operations. April 21, 2007.
[4] City of New York. *PlaNYC brochure*. December 2007. Accessed at http://www.nyc.gov/html/planyc2030/downloads/pdf/planyc_brochure.pdf on July 23, 2007.
[5] Figure 1 is slightly misleading in that it refers to the amount of *in-city* energy supply available to satisfy local power needs. There is an additional 5,000 MW of transmission capacity capable of delivering electricity to New York City from upstate New York, Long Island, and New Jersey. What the City is emphasizing is how in-city supply capacity will fall short of the "80% rule," a state requirement that New York City maintain in-city power generation capacity equal to 80% of the anticipated local summertime peak demand. This requirement is based on a statistical estimate of the risk of simultaneous failure of both in-city generation capacity and transmission lines importing power to the city. At this 80% level, it is considered unlikely that the city would be vulnerable to a major power outage. Should there be a significant change in the amount of transmission capacity into New York City, this requirement could be revised downward.
[6] City of New York. *PlaNYC brochure*. December 2007. Accessed at http://www.nyc.gov/html/planyc2030/downloads/pdf/planyc_brochure.pdf on July 23, 2007.

The recent long term growth and sustainability plan released by the Mayor – also known as *PlaNYC* – details a variety of approaches upon which it suggests the city rely to eliminate or reduce the size of this anticipated supply gap. **This report examines the viability of one of the technologies cited in *PlaNYC* – the use of small scale,[7] distributed power generation systems known as combined heat and power (CHP) technology.**

As the name implies, combined heat and power refers to the simultaneous generation – or cogeneration – of heat and electricity by technology located at or near the point where the energy will be used. CHP systems are designed to capture and use the waste heat produced in the power generation process to satisfy some type of on-site thermal demand, such as steam, hot water, or cooling loads.[8] Compared to conventional power generation in large central station power plants,[9] a CHP system is on average more than twice as efficient in terms of its fuel input-to-energy output ratio, meaning that the same amount of energy can be produced with less than half the amount of fuel. CHP systems can similarly offer sizable reductions in greenhouse gas emissions over conventional heat and power systems.

Because CHP is an on-site energy source, an additional benefit is that electricity generated by the system averts the losses inherent in the transmission and distribution of electricity over the grid.[10] CHP can also reduce costly investments by distribution utilities to maintain or expand their grid infrastructure, decrease grid congestion, and translate into lower, more stable electricity rates for consumers.[11] Due to these many technical, economic and environmental benefits, CHP deserves scrutiny as to whether it can play a more prominent role in powering New York City. That is the purpose of this report.

CHP Growth Trends

CHP deployment levels are growing around the world. By 2004, distributed generation – of which CHP comprises the vast majority – was responsible for 7.2% of world electricity generation capacity, up from 7% in 2003.[12] In 2006 the International Energy Agency launched an initiative designed to promote CHP use,[13] while the World Alliance for Distributed Energy (WADE) has been actively promoting CHP deployment in partnership with national CHP trade associations, especially in China and India.[14] The US has also witnessed a steady increase in cogeneration system deployment, as indicated in Figure 2 below.

[7] In this report we focus on CHP systems capable of generating 10 MW of electric power or less. This is a somewhat arbitrary threshold, but we believe it serves to differentiate between systems capable of serving one or several buildings close to the point of generation and those designed to serve scores or hundreds of buildings through a much larger 'district energy' scheme. There are a handful of other CHP systems around the city, but they are very large, with some capable of generating over 100 MW of electric power – a quantity larger than some central station 'peaker plants' operating around the city.

[8] CHP systems can cool buildings through the use of absorption chillers that use waste heat to activate a refrigerant solution. These systems are sometimes called combined cooling, heat, and power (CCHP) or "tri-gen" systems. For more information, see http://uschpa.admgt.com/TB_TAchillers.pdf.

[9] Central station power plants are predicated on the model that large quantities of power are generated at a single facility, with power sent over transmission and distribution lines to electricity customers. Distributed generation emphasizes energy production at the point of use.

[10] These losses occur as the electricity traveling through a wire or transformer begins to heat the wire/transformer. This heat represents an inefficiency that reduces the amount of power ultimately delivered to the end user. In general, 92-94% of the electrons entering the wire at a power plant actually make it to the final destination/user.

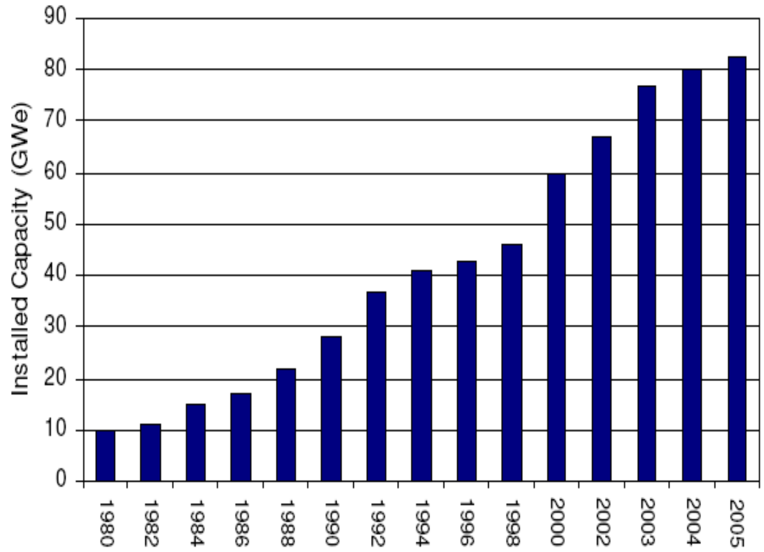
[11] Northwest CHP Application Center. *Applications Manual* (website). Accessed at http://www.northeastchp.org/nac/cases/manual.htm on July 28, 2007.

[12] WADE, *World Survey of Decentralized Energy*, 2006.

[13] See International Energy Agency initiative at www.iea-dhc.org.

[14] See World Alliance for Distributed Energy (WADE) at www.localpower.org.

Figure 2
Cogeneration Capacity in the US[15,16]



Among cities, London stands out as a leader in small-scale CHP system policy. Thanks to three-year old rules[17] requiring developers of large new building projects to examine the viability of CHP technology, interest in the technology has expanded greatly. There are currently more than 50 'low-carbon' development schemes under development in London, a sizable number of which include CHP projects as a fundamental part of the onsite energy system. These CHP projects will collectively double or triple total current installed CHP system capacity in greater London.[18,19] London's recently released climate change action plan aims to capitalize on this trend, prioritizing CHP deployment as a central feature of its greenhouse gas reduction strategy. Ultimately, the Mayor of London hopes to deliver 25% of the city's energy – totaling thousands of megawatts of capacity – from distributed sources (like CHP) by 2025.[20]

CHP in New York City

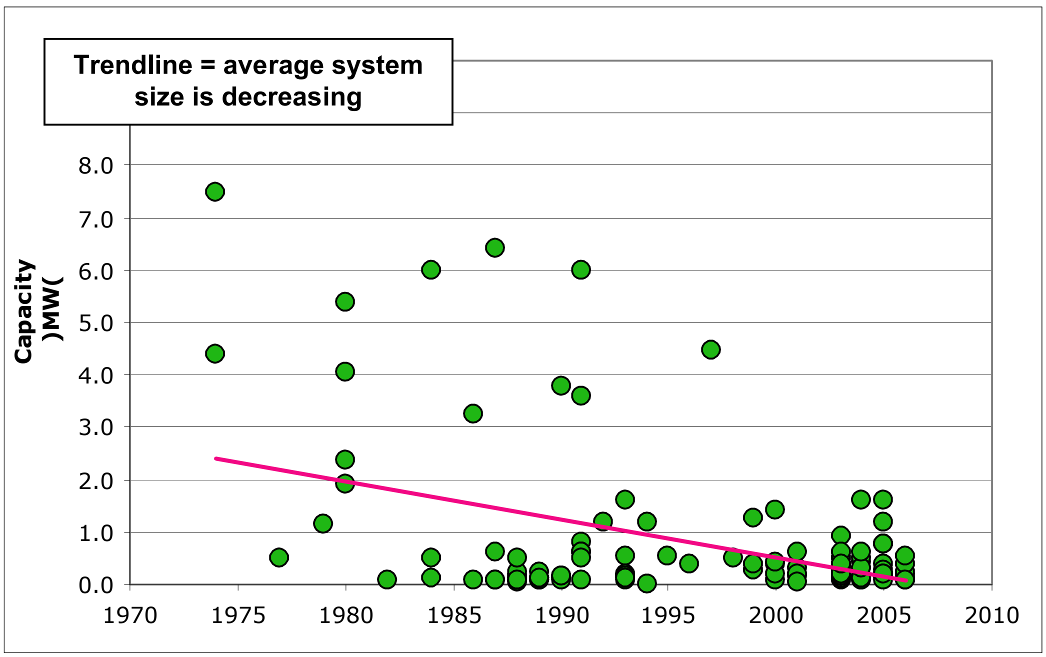
Large-scale cogeneration of heat and power is long-established in New York City. There are 8 large cogeneration systems in the city, rated between 10.5 and 360 MW in capacity. The largest of these is Con Edison's East River cogeneration plant, which provides electricity and steam to Manhattan residents. However, small-scale CHP – which is the focus of this report – plays a relatively minor role in New York City's current electricity generating capacity picture. There are

[15] Source: WADE World Survey of Decentralized Energy, 2006. pg. 2. Accessed at http://www.localpower.org/documents/report_worldsurvey06.pdf on July 23, 2007. Data for graph compiled from Energy and Environmental Analysis, Inc. CHP Installation Database at http://www.eea-inc.com/chpdata/.
[16] Note: this table reflects total cogeneration power capacity in the US, including large scale installations. It thus overstates the level of small-scale CHP system deployment; we were unable to identify any data detailing the total US installed capacity of the smaller systems, which are the focus of this report.
[17] Greater London Authority. *Green light to clean power: The Mayor's Energy Strategy.* February 2004.
[18] Communication with Tatiana Bosteels, Climate Change Manager, London Climate Change Agency. August 9, 2007.
[19] The UK Department of Trade and Industry reports that there is currently approximately 37 MW of small-scale (<10 MW) CHP capacity deployed in London, at 8 sites. The DTI data does not track systems below 1 MW, so it is likely that this number underestimates the true current deployment level by some small amount. Source: London Climate Change Agency List of Low-Carbon Sustainable Projects in London.
[20] Greater London Authority. *Action Today to Protect Tomorrow: The Mayor's Climate Change Action Plan.* February 2007.

135 small-scale CHP systems currently deployed in commercial, residential, and industrial applications across the five boroughs, with an aggregate generating capacity of approximately 118 MW. This amounts to approximately 1% of the current in-city generating capacity. Deployment levels are on the rise, however; as shown in Figure 3, 75% of all CHP systems deployed in New York City were installed after 1990, with the biggest surge occurring after 2001, when the New York State Energy Research and Development Authority (NYSERDA) began subsidizing CHP installations.

Most of the systems installed in New York City are capable of generating less than 2 MW of power. Some local projects are extremely high profile, such as the systems installed at the Conde Nast building in Times Square, the Equity Office tower on 5th Avenue, and the Sheraton Hotel and Towers in midtown Manhattan. The new Bank of America building at One Bryant Park will include a 5.1 MW CHP system, and in the next few years a fuel-cell based CHP system is scheduled to be installed in the new Freedom Tower, which is presently under construction in lower Manhattan. The Freedom Tower system will total 4.8 MW of generation capacity – one of the largest fuel cell system installations in the world.[21]

Figure 3
New York City CHP Installations and Capacities (1974-2006) [22]

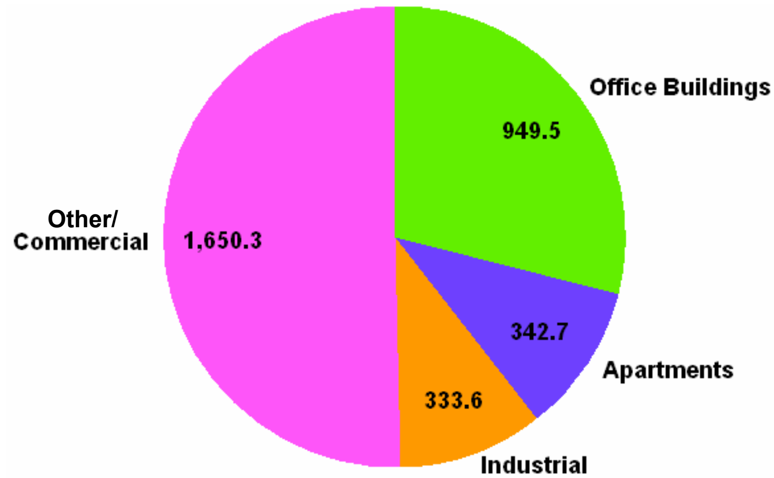


Current CHP deployment levels represent just a fraction of what could be deployed in New York City. A 2002 report prepared for NYSERDA estimated the technical CHP potential in the Con Edison service territory[23] at approximately 3,200 MW.[24] These estimates were based on the

[21] "World Trade Center complex will include 4.8 MW of fuel cell plant." *Cogeneration & On-Site Power*. September 20, 2006.
[22] Synthesis of datasets provided by Environmental and Energy Analysis, Inc. (EEA) and NYSERDA. The EEA dataset (available on-line at http://www.eea-inc.com/chpdata/States/NY.html) was accessed in November 2006 while the NYSERDA database was current as of January 2007. Though the databases list 135 CHP projects in New York City, only 122 include project dates. The figure above reflects these 122 projects.
[23] Con Edison provides electric transmission and distribution service in both New York City and Westchester County, directly north of the city. Although the NYSERDA report did not break out the potential for New York City, since demand in the city is roughly 87% of Con Edison's total territory-wide demand, we can rather crudely estimate that the overwhelming majority of this CHP potential is in New York City.

projected power and thermal loads at local (existing) manufacturing and institutional/commercial facilities. The estimates do not take into account new construction or changes in energy demand occurring since 2002. They also do not reflect the significant population growth now anticipated to occur in the city by 2030.[25]

Figure 4
CHP Potential in Con Edison Service Territory
(total megawatts per sector) [26]



As Figure 4 displays, the greatest potential for additional CHP deployment in the Con Edison service territory is in the commercial/institutional sector, including hotels, restaurants, commercial laundries, hospitals, universities, and other schools. Nearly 4,600 buildings in this sector were estimated to have an aggregate deployment potential in excess of 1,650 MW. In addition, there are another 4,100 office buildings representing 950 MW of potential.[27, 28]

New Targets vs. Long-standing Impediments

New York City's new long-term growth and sustainability plan, known as *PlaNYC*, suggests tapping local CHP deployment potential as one means of addressing the city's looming electricity supply shortfall. It recommends the City work to achieve a target of 800 MW of deployed CHP capacity by 2030.[29] *PlaNYC* is silent on how that level of deployment should be realized, which sectors should be targeted, or what system size or CHP technology mix should optimally be pursued in the city.

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[24] New York State Energy Research and Development Authority. *CHP Market Potential for New York State (Final Report 02-12)*, October 2002.
[25] City of New York. *PlaNYC: A Greener, Greater New York*. Office of Long Term Planning and Sustainability, New York City Office of Operations. April 21, 2007.
[26] New York State Energy Research and Development Authority. *CHP Market Potential for New York State (Final Report 02-12)*, October 2002. pg A-4.
[27] Ibid.
[28] It is worth noting that the NYSERDA study believes the average CHP system size in these sectors will be rather small: Commercial/industrial sector = 1,650 MW projected capacity ÷ 4,600 buildings = ~ 360 kW/installation. Office building sector = 949.5 MW projected capacity ÷ 4,100 buildings = ~232 kW/installation. In both cases, these estimates echo current on-the-ground trends where the average installed CHP system size has declined significantly. [See Figure 3]
[29] City of New York. *PlaNYC: A Greener, Greater New York*. Office of Long Term Planning and Sustainability, New York City Office of Operations. April 21, 2007.

As this report will explain in detail, achieving *PlaNYC*'s deployment target – or New York City's much larger projected CHP potential – may prove challenging given current regulatory and market conditions. Although CHP technology has been around for many decades, it is far from being a 'plug and play' technology, meaning a building owner can't simply buy a system off the shelf and plug it into their building's electricity and thermal energy distribution system. Successful CHP system deployment generally requires interconnection with the existing grid and access to the local natural gas supply infrastructure. While the PSC has adopted rules intended to facilitate installation of CHP systems under 2 MW, Con Edison has the right to set the technical requirements for interconnection projects of any size. As a result, the viability of most local CHP system installations will be heavily influenced by Con Edison's decisions regarding interconnection to their electric grid. This issue is discussed at length throughout this report.

Since 2005, another important factor influencing CHP system deployment has been the New York City Fire Department's (FDNY) refusal to sign off on permit applications for microturbine CHP systems due to their reliance on a high pressure gas feed. The FDNY apparently adopted this stance in the wake of September 11th, perhaps out of a heightened concern about the additional safety hazard involved when fighting a fire in a high-rise building with a high pressure gas line. A task force composed of members of the FDNY, the New York City Department of Buildings, and others met during 2006-2007 to resolve this issue. We discuss this topic at some length, describing how this problem has stymied microturbine deployment at great cost to system owners and developers.

Purpose and Structure of this Report

The subject of this report was selected in consultation with the Energy Department at the New York City Economic Development Corporation (EDC), the unit which serves at the principal energy policy advisor to Mayor Michael Bloomberg. Although this report was prepared for the benefit of EDC, it is not an official agency publication and does not necessarily represent the views of the City of New York. Though EDC is intended to be the primary audience for this report, we have designed it to be relevant and accessible to policymakers and other stakeholders interested in the potential role of CHP technologies within the New York City energy marketplace.

This report explores CHP on several fronts. Section 2 examines five specific CHP technologies, including steam turbines, combustion turbines, reciprocating engines, fuel cells and microturbines. Because CHP systems operate quite differently depending on the technology used, we believe this explanation will help the reader understand the merits, limitations, and potential applications of each technology. The CHP technology section also includes an in-depth analysis of the interconnection of these systems to the local electricity grid which – as noted – is a significant barrier to many projects already underway and other projects under consideration.

Section 3 explores the policy and regulatory environment for CHP in New York City, including federal, state, and local policies and regulations that have helped or hindered local projects. Section 4 builds on the policy/regulatory chapter by examining how these issues affect the economic prospects of a CHP project. The report concludes with a bottom-line assessment of the prospects for CHP technology in New York City, and recommendations on steps the New York City Economic Development Corporation's Energy Department can take to facilitate the further deployment of CHP around the city. Ultimately, New York City's realization of its goal for increased CHP deployment, as well as the benefits associated with it, are contingent upon making CHP more of a seamless, 'plug-and-play' technology.

There are several caveats to this report. First, the reader seeking definitive cost data on local projects will likely need to keep looking for that elusive information. Although we report on local project economics, there is no such thing as a standard CHP system. Each installation has specialized load needs, thermal needs, unrealized efficiency savings, space requirements and user sensibilities, all of which influence a project budget. Research seeking to detail the actual cost of local installations would be a welcome addition to the local policy literature.

This report also does not attempt to compare the cost or viability of CHP technology to other energy options in a building, such as the deployment of renewable power systems or the pursuit of energy efficiency initiatives. In preparing this report, we presume the reader has already considered such issues on their own.

In the course of our work, the research team came across claims that overall gas consumption within New York City could significantly *decrease* with increased CHP deployment, due to offsets of central power plant electricity generation.[30] We have chosen not to address this point in our study, due to the fact that CHP deployment levels would have to be quite high for overall gas consumption to decrease, and such a situation is likely not realistic in the near term. Nevertheless, the effects of CHP use on gas consumption remains a point worthy of further exploration.

Finally, we caution the reader that CHP system deployment is a highly technical subject. In our discussion of interconnection and fault current issues, we do not attempt to recount every technical detail, nor do we provide firm guidelines for pursuing interconnection of a CHP system. The discussion of these issues has been deliberately structured so it is accessible to non-engineers. Those seeking detailed technical information are encouraged to look at the Con Edison distributed generation website[31] and within their EO-2115 specifications, addressed later in the report.[32]

Given the resources and study period available, the technical nature of the subject matter also limited the array of topics the graduate student research team was capable of addressing. As a result, we were unable to explore at depth the 'reasonableness' of Con Edison's interconnection rules, a subject of tremendous interest to local stakeholders. This too is an area ripe for additional analysis, a point we make in the final chapter.

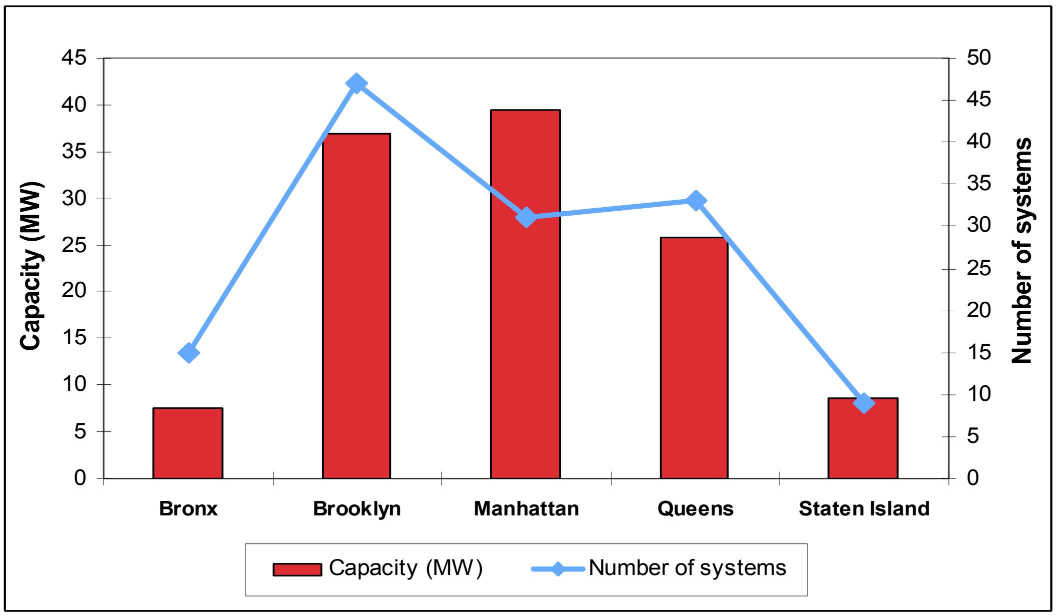
We hope this report helps local policymakers and other interested parties understand the opportunities and limitations presented by this technology, advancing the local dialogue on strategies to better integrate CHP use into the New York City energy supply picture.

[30] For more information, see Environmental and Energy Analysis, Inc. *Natural Gas Impacts of Increased CHP*. Prepared for the U.S. Combined Heat and Power Association, October 2003. Accessed at http://www.eea-inc.com/dgchp_reports/CHPA-Gas.pdf on August 9, 2007.
[31] See http://g050-w5.coned.com/dg/.
[32] See Con Edison. *Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers*. March 2006. Accessed at http://m020-w5.coned.com/dg/specs_tariffs/EO-2115.pdf.

Section 2: An Introduction to CHP Technology and Key CHP Technology Issues

Combined Heat and Power (CHP) systems have been an important part of New York City's electric power system for several decades. One of the first systems was installed in the 1950s at the old Domino Corporation sugar processing plant in Brooklyn, providing both electricity and steam to the facility. **By our best estimate, today there are 135 small-scale (<10 MW) CHP systems deployed around New York City, with an aggregate capacity of 118 MW.**[33] **This represents a small part—approximately 1%—of New York City's total in-city generation capacity.**[34] CHP installations are found in each borough in commercial, residential, industrial, and institutional applications. Figures 5, 6, and 7 contain various breakdowns of New York City's small-scale CHP systems by borough, number, aggregate electricity generating capacity, and the nature of the building or complex of buildings in which they are deployed.

Figure 5
Total Installed Capacity and Number of Small-Scale CHP Systems in New York City (by Borough)



[33] This data is based on information found in datasets maintained by Environmental and Energy Analysis, Inc. (EEA) and the New York State Energy Research and Development Authority (NYSERDA). The EEA database is considered to be the most authoritative on this subject, although it relies on voluntary reporting of CHP system installations. As a result, it may underrepresent the total number of systems installed around New York City. NYSERDA's CHP system database includes projects which have received some type of financial support from the agency. See Appendix 5 for a list of all CHP systems in New York City derived from combining these two databases.

[34] Total in-city power generation capacity is estimated by the New York City Economic Development Corporation to be approximately 10,305 MW. This includes capacity installed in New Jersey that is dedicated to the New York City power supply system. Source: Presentation by Craig Wilson, Senior Project Manager, New York City Economic Development Corporation Energy Department, at Columbia University. January 18, 2007.

Figure 6
Total Installed Capacity and Number of Small-Scale CHP Systems in New York City (by Application)

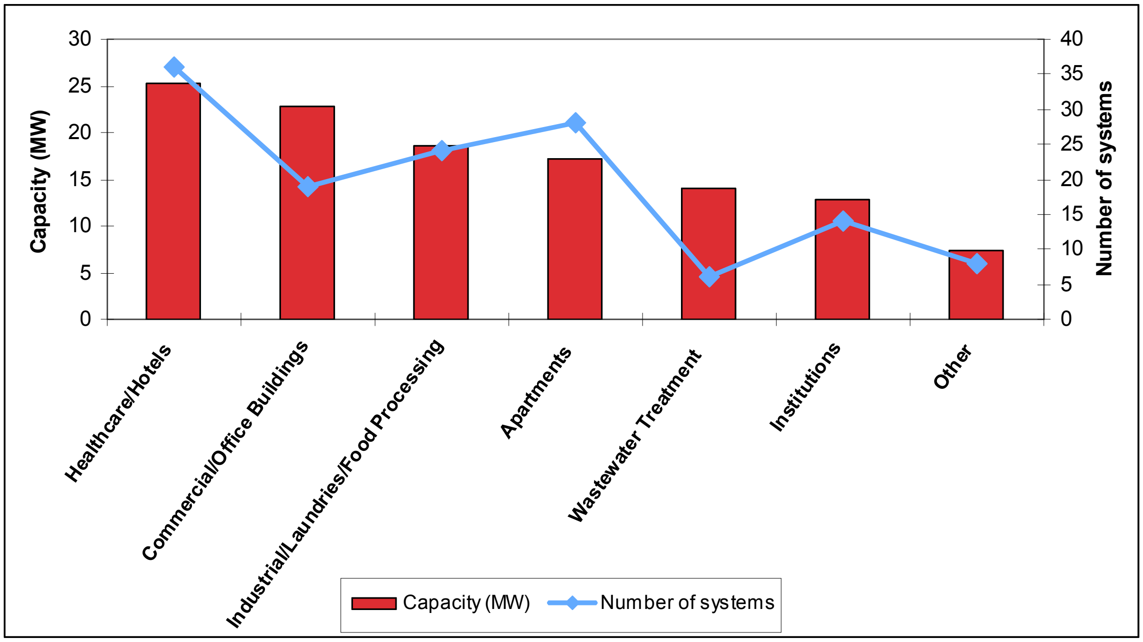
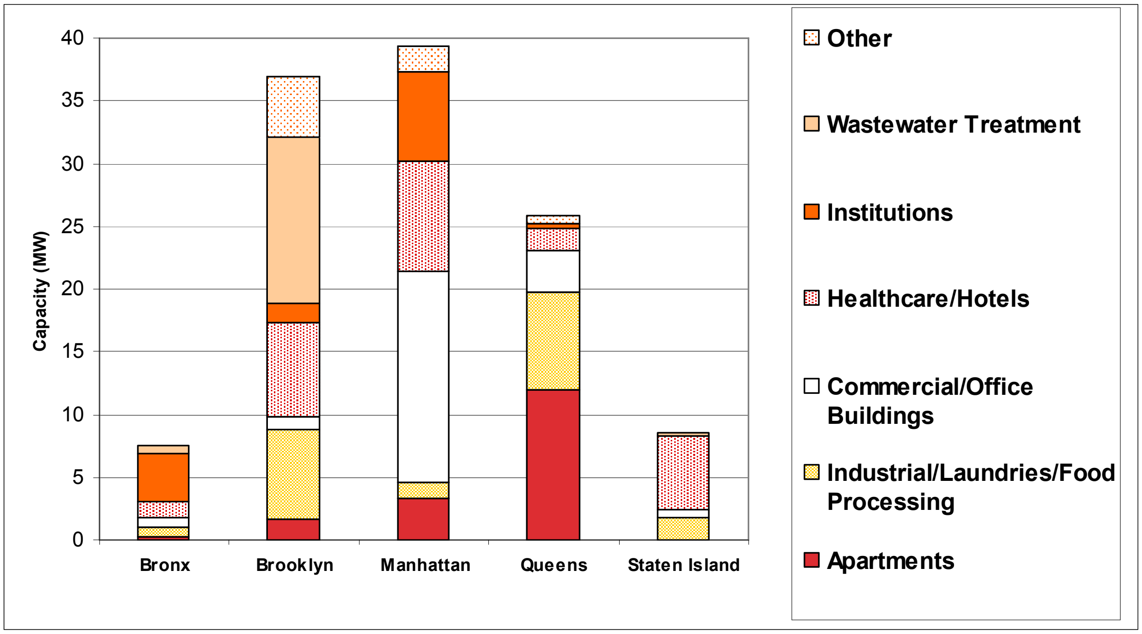


Figure 7
Total Installed Capacity of Small-Scale CHP Systems in New York City (by Application and Borough)



Given that there are 950,000 buildings in New York City,[35] relatively low CHP deployment numbers hint at a larger set of issues involved with CHP use. In this section, we provide basic background information about CHP technology and the specific technologies deployed here in New York City. The majority of this section, however, is taken up with a lengthy explanation of the challenges posed by the interconnection of CHP systems to the local electric grid. These challenges are by no means unique to New York City, but they amplify how difficult it may be to achieve the City's new deployment target. In subsequent sections of this report, we highlight other issues that affect CHP viability, but at the end of the day interconnections remain the key challenge that portend how prominent a role this technology will play in New York City's energy future.

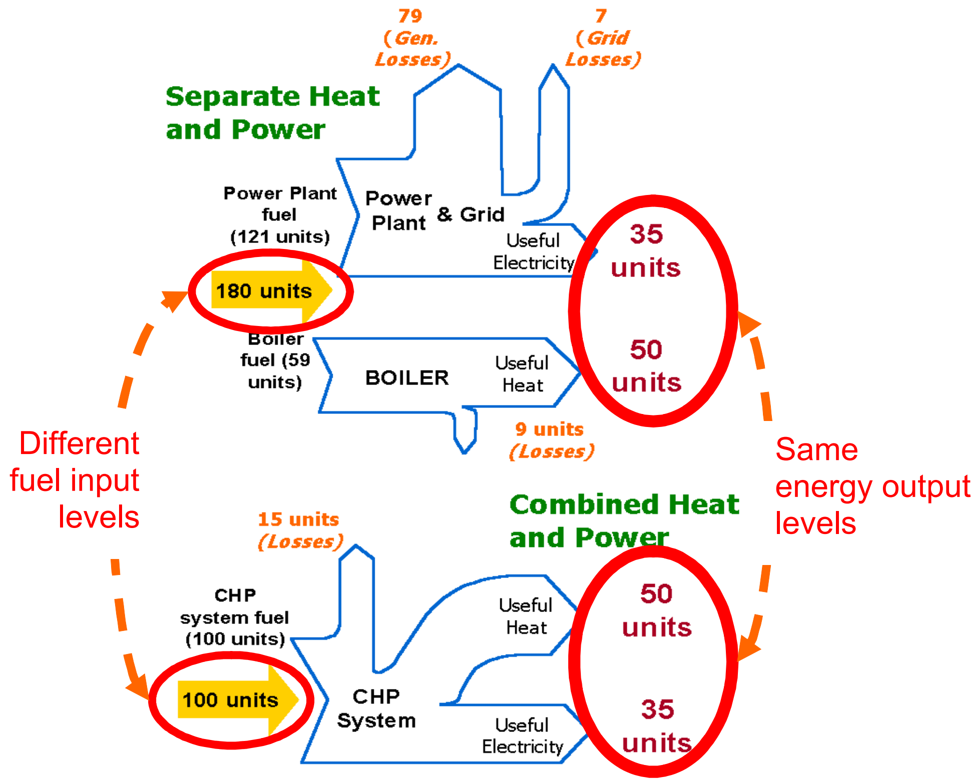
The Fundamentals of CHP: The Benefits of Cogeneration

As the name implies, CHP systems simultaneously produce two forms of usable energy: electricity and heat. Depending on the type of CHP technology deployed, electricity may be generated in different ways, but one constant is the fact that waste heat from the electricity generation process – which would normally be released into the air or adjacent waterway – is instead captured for some productive use. This can include hot water production, space heating, space cooling (through the use of an absorption chiller), or process heat for industrial applications. By contrast, most large central station power plants do not seek to capture the waste heat in any form, meaning they are fundamentally less efficient in their fuel use.

Figure 8 depicts this situation, comparing two alternative approaches for delivering electric and thermal energy to a building. The top portion of the drawing portrays a building that derives its electricity from a traditional power plant, while its heating/hot water/cooling needs are satisfied by an on-site boiler or chiller. The bottom portion of the drawing depicts an alternative approach to providing these same energy services, relying on CHP technology. As the figure makes clear, because the relative efficiencies[36] of the different technologies vary so greatly, it takes vastly different amounts of fuel <u>inputs</u> to deliver the same level of usable energy <u>outputs</u>.

[35] City of New York. *PlaNYC: A Greener, Greater New York*. Office of Long Term Planning and Sustainability, New York City Office of Operations. April 21, 2007. pg. 135.
[36] In this case, efficiency is defined as the proportion of the energy value of the fuel input that is actually captured as a usable output (electricity, water and space heating/cooling, etc.)

Figure 8
Comparison of Efficiencies: CHP vs. Separate Heat and Power Systems



Source: Modified from American Council for an Energy-Efficient Economy (ACEEE)

CHP Technology Profiles

All CHP systems enjoy a basic efficiency advantage over conventional separate heat and power systems. Nonetheless, the individual characteristics of different CHP technologies can vary significantly. CHP systems differ not only in their generating capacity – depending on the specific technology employed, they will also vary in terms of footprint, fuels used, cost per kilowatt of electricity produced, amount of heat produced, operating characteristics, and emissions levels. A chart comparing key characteristics of various CHP technologies can be found in Appendix 1.

The range of technologies available has helped make CHP a viable option for a wide variety of applications, but has also made it necessary to choose the technology best suited to a building's heat and power – and budgetary – requirements. Below is a brief profile of the primary CHP technologies employed in New York City, while the sidebar on CHP Metrics explains some of the most salient technical characteristics that decisionmakers will consider when choosing among the different systems.

– ***Steam Turbine CHP systems***: Steam turbine-based CHP systems represent "old technology" and are typically used in large-scale district heating and industrial applications. The largest steam turbine CHP system in New York City is Consolidated Edison's 300 MW steam and power cogeneration plant on 14th Street in Manhattan.[37] One of the smaller-scale steam turbine-based CHP systems in New York City is New York University's 6 MW steam turbine located in Greenwich Village. This oil-fired system has been operating since 1984, and is in the process of being replaced by a 15MW natural gas-fired turbine unit.

– ***Reciprocating Internal Combustion (IC) Engine CHP systems***: The reciprocating internal combustion engine is an established technology used in 104 out of 135 of the small-scale CHP systems currently deployed in New York City. In the near term, reciprocating engines may continue to be the principal technology employed in new CHP systems installed in New York City, due to low initial costs, a wide capacity range, and general familiarity with the technology.[38] The previous trend of using diesel-fueled reciprocating engines is now shifting towards natural gas-fueled engines due to evolving technology and concerns regarding the relatively high level of air emissions produced by diesel-fired installations.

– ***Combustion Turbine CHP systems***: Like steam turbine technology, combustion or gas turbine technology found its original application in central station commercial power generation. However, it has also been used in institutional CHP applications in New York City. Rockefeller University, located on the Upper East Side of Manhattan, has an 800kW oil-fired, combustion turbine-based CHP system that has been operating since 1991. Weill Cornell Medical Center on the Upper East Side of Manhattan is in the process of installing a 7.5MW natural gas-fired, combustion turbine-based CHP system.

– ***Microturbine CHP systems***: At approximately the size of a refrigerator, microturbines are essentially small combustion turbines which operate using both the mechanical and combustion energy of high-pressure gas. They offer a number of potential advantages over other technologies for small-scale CHP generation, including their small number of moving parts, compact size, light weight, greater efficiency, lower emissions, and

Box 1
Key CHP System Metrics

Capacity: The maximum electrical power a CHP system can produce at any given moment, measured in watts (W), kilowatts (kW, thousands of watts), or megawatts (MW, millions of watts).

Footprint: The amount of floor space the CHP system will occupy, measured in ft^2/kW of system capacity.

Fuels: The energy input selected for the CHP system. Can include diesel, natural gas, fuel oil, biogas, solid waste, biodiesel and hydrogen.

Thermal Output: A measure of the BTUs of usable heat produced/kWh of electricity produced.

Heat Temperature: The temperature of the heat recovered from the CHP system. Different applications, particularly industrial process heating applications, may require higher temperature heat than water/space heating or chilling applications.

Efficiency: The level of useful energy outputs produced per unit of energy input.

Start-Up Time (Black-Start Time): The time it takes for a generating unit to reach its operating capacity after it is started. This figure is particularly relevant in buildings intending to rely on a CHP system in the event of grid blackout.

Emissions: The level of regulated pollutants emitted by the CHP system. The most important pollutants generally include NOx (which causes smog), SO_2 (responsible for acid rain), CO_2 (responsible for global warming), and particulate matter (responsible for local public health concerns).

Noise: CHP systems produce varying levels of noise while operating, which may be a concern for many applications. Some CHP technologies require a specially-built enclosure to reduce noise to acceptable levels, while others have this feature built into the system. Fuel cells operate so quietly they require no enclosure at all.

[37] Given its massive size, we do not consider this power plant or other large steam turbine systems to be relevant to this report's focus on small (<10MW) scale CHP systems. Source: New York City Steam Development Task Force, *Steam Business Development Plan for the Consolidated Edison Steam System*. August 26, 2005.
[38] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002. pg. 2-3 and 2-4.

the ability to use biofuels. Additionally, microturbines operating in an inverter-based generation configuration produce negligible levels of fault current, which may make them a preferable technology in areas with limited fault current margin.[39] This point is discussed in greater detail below. Microturbines have become increasingly popular options for CHP in recent years, but they have faced significant deployment obstacles. [See Section 3 for further discussion.] The Clinton Hill Apartments in Brooklyn recently installed 12 natural gas-fired microturbines, yielding a total of 540 kW installed capacity.

– ***Fuel Cells***: Representing a radical departure from the engine or turbine-based technologies discussed above, fuel cells generate electricity and heat through a chemical reaction.[40] The high costs and relative immaturity of fuel cell technology will likely prevent it from becoming an economically viable option for most mainstream applications in the short term. Fuel cells will generally prove most appealing in applications in which low emissions and noise profiles are paramount, or for organizations eager to deploy cutting-edge technologies. Since their inverter-based generation configuration effectively eliminates the fault current problem discussed at length below, fuel cells may also be preferred in areas with limited fault current margin.[41] Several fuel cell systems have been installed around New York City, in hotels and office towers. Fuel cells have also been installed at local wastewater treatment facilities, where they operate using biogas generated on-site.

A sixth type of technology, generically known as 'micro-CHP', is discussed in Appendix 4. Sized primarily to meet the electricity or thermal needs of an individual home or small business, micro-CHP systems are gaining recognition and use in Japan, where more than 50,000 units have been installed to date. This technology is worth watching, as it may represent a paradigm shift that could revolutionize the local energy marketplace. This technology is still in its infant stages here in the US, however, and for that reason, we have opted to primarily focus on the larger-scale technologies cited above that are already being deployed around New York City.

Figures 9 and 10 show three key trends in local CHP use. Figure 9 breaks down CHP deployment levels by technology over the last thirty years. Reciprocating engines are by far the most common technology choice, likely due to the fact that these engines are a familiar, established CHP technology available in a wide range of system sizes.[42] Fuel cells and microturbines are both relatively new technologies that are quickly gaining in popularity. In the case of microturbines, this is likely due to the fact that it is the only CHP technology eligible for federal incentives, a situation discussed in the next section of the report

The second key trend is the sharp increase in overall CHP deployment, probably linked to the decision by NYSERDA to begin subsidizing CHP projects in 2001. Fully 40% of the small-scale CHP systems deployed around the city have been installed since these subsidies became available, hinting at how critical financial assistance can be in driving deployment decisions.

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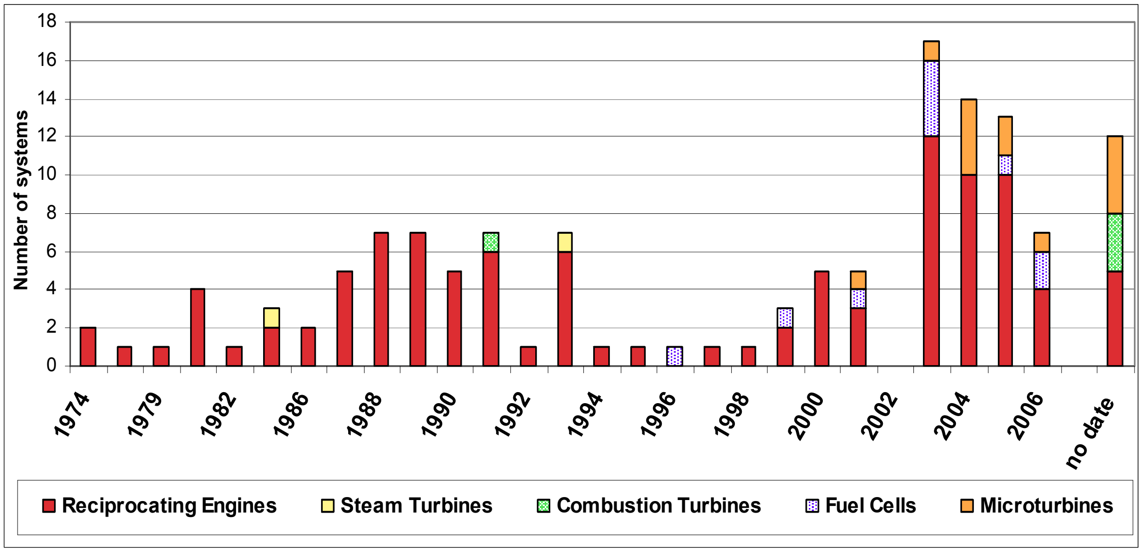
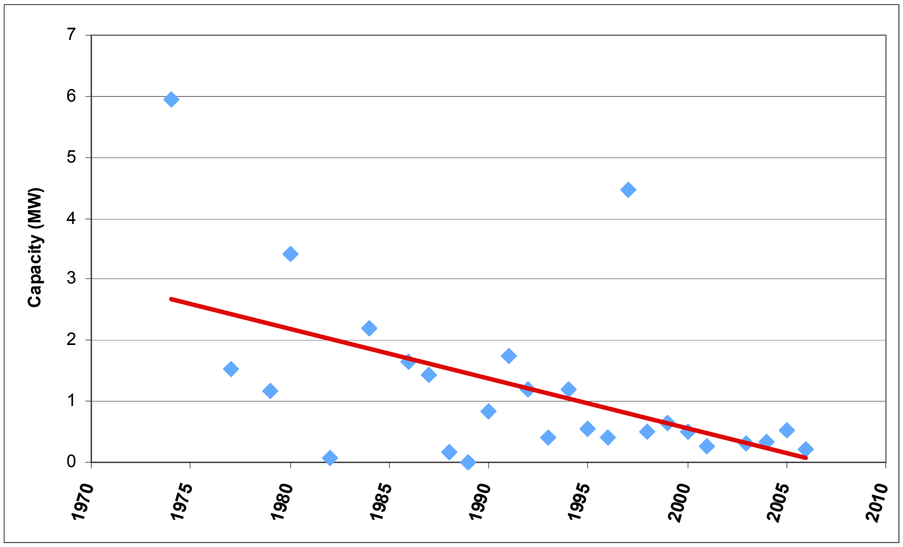
[39] Communication with Cory Glick, President, Cogeneration Contractors, July 27, 2007.
[40] Other engine and turbine-based CHP technologies generate heat in the fuel combustion process. The mechanical energy resulting from combustion is used to turn a generator, which produces electricity.
[41] NYSERDA and the Collaborative. *Consolidated Edison Electric Rate Case Action Plan*, August 16, 2005. See pg. 38, footnote 3.
[42] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002. pg. 8-12.

Figure 9
Number of CHP Systems Installed in New York City
(by Technology Type) (1974-2006)



The final noteworthy trend is the decreasing average size of CHP systems being installed around New York City. Since 1974, the average system size has decreased by nearly 70%. [See Figure 10] Microturbines and fuel cell installations tend to be smaller, partly explaining the most recent average system size figures, but it is not clear what factors were driving this phenomenon during the 1980s and early 1990s. This is one area where additional research may be beneficial.

Figure 10
Average Size of New Installed Small-Scale CHP Systems in New York City
(1974-2006) [43]



[43] In order to avoid distortion of the graph, years during which no new systems were installed were excluded from the graph.

CHP Emissions Issues

Though the increased efficiency of CHP results in lower overall emissions levels than separate heat and power systems, emissions are nonetheless an important point of consideration when selecting a CHP technology. Because nearly all CHP systems burn fossil fuels, the immediate area in which they are sited may experience somewhat diminished air quality, particularly if there are no pre-existing electricity generation sources in the area.

The level and type of pollutants emitted by a CHP system will generally include particulate matter (PM), volatile organic compounds (VOCs), oxides of nitrogen (NOx), oxides of sulfur (SOx), carbon monoxide (CO), and carbon dioxide (CO_2).[44] Due to New York City's generally poor air quality, siting and permitting a CHP system which emits high levels of regulated pollutants can be an expensive and lengthy process.[45, 46]

Several publications have detailed the generic emissions profile of different CHP technologies.[47] [See Appendix 2 for summary.] This information is of limited use to local project developers, however, because emissions tend to be project specific, and will vary according to the technology selected, the system size, efficiency, and fuel source.

Despite these limitations, there are nonetheless several general comments that we can make about CHP system emissions.

First, most local CHP systems rely on natural gas as their fuel source, and most new combustion-based CHP systems will be natural-gas fired. Natural gas produces fewer emissions than other fuels; in particular, natural gas CHP systems do not emit significant levels of SOx or PM,[48] though they can emit higher levels of CO or NOx, particularly if the combustion process is not properly regulated.[49,50] Net CO_2 emissions in combustion-based systems decline as system efficiency increases; therefore, increasing thermal capture over 50% is useful in attaining minimal CO_2 emissions from gas-fired CHP units.[51]

Second, as we note in Section 3, New York City is considered a moderate non-attainment area for PM and CO, and a severe non-attainment zone for NOx and VOCs.[52] As a result, technologies that minimize these pollutants – particularly below levels that would designate the system as a 'major' source of emissions – will likely have an easier time obtaining an air permit.[53]

Third, combustion turbines and microturbines tend to be among the cleaner CHP technologies, but this can vary widely according to their load levels. Though combustion turbines are designed to operate most efficiently at high loads, NOx emissions are also greater at high loads due to

[44] Energy Nexus Group. *Introduction to CHP Catalogue of Technologies*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002. pg. 11.
[45] New York State Department of Environmental Conservation. "Air Pollution Control Permit Program: Is This Project Major or Minor?" Accessed at http://www.dec.ny.gov/permits/6244.html on August 2, 2007.
[46] Energy Nexus Group. *Introduction to CHP Catalog of Technologies*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002. pg. 2.
[47] These publications include: 1) NYSERDA, *CHP Market Potential for New York State (Final Report 02-12)*. October 2002; 2) Energy Nexus Group, *Catalogue of CHP Technologies*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002; 3) National Renewable Energy Laboratory and the Gas Research Institute. *Gas-Fired Distributed Resource Energy Technology Characterizations*. October 2003.
[48] Communication with Tim Daniels, Director of Government Affairs - New York and New Jersey, Constellation Energy. August 17, 2007.
[49] Energy Nexus Group. *Technology Characterization: Gas Turbines*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002. pg. 19.
[50] National Renewable Energy Laboratory and the Gas Research Institute. *Gas-Fired Distributed Resource Energy Technology Characterizations*. Reciprocating Engines. October 2003. g. 2-9.
[51] Communication with Tim Daniels, Director of Government Affairs - New York and New Jersey, Constellation Energy. August 17, 2007.
[52] New York State Department of Environmental Conservation. "Air Pollution Control Permit Program: Is This Project Major or Minor?" Accessed at http://www.dec.ny.gov/permits/6244.html on August 2, 2007.
[53] Ibid.

higher combustion temperatures. Reducing load, however, increases CO and VOC emissions.[54] Similarly, microturbines operated at full load are designed to have very low emissions, though operating them at partial load often leads to higher emissions levels.[55] CHP system developers will need to factor these issues into their deployment strategy, recognizing that certain operating decisions may result in an easier or more difficult permitting process.

Fourth, in almost every category fuel cells have the lowest emission levels, since they do not require a combustion process to generate power. If pure hydrogen is used in a fuel cell, the only emission is water vapor. If another type of gas is used to fuel the system, there will be some emissions, although generally at very low levels.[56]

Lastly, emissions from CHP systems can be controlled by various methods during and/or after combustion, such as by limiting the air and temperature in the combustion chamber, 'scrubbing' the exhaust with a water vapor mixture as it leaves the system, and using catalytic processes.[57] If the optimal CHP system for a particular site is not one of the lowest-emitting technologies, using some of these techniques may be necessary if the system is to win permit approval from state air quality officials.

Interconnection with the Local Electric Grid: CHP Technology's Achilles Heel

Note: This section does not attempt to present the reader with the specific guidelines for interconnecting a CHP system in New York City. For this highly technical and detailed information, we point the reader to the Con Edison distributed generation website and/or EO-2115 specifications available at http://m020-w5.coned.com/dg/. The purpose of this discussion is to present a simplified, bottom-line view of interconnection issues in an effort to make this complex subject more accessible to the non-technical reader.

Unquestionably, the most important technology issue relating to CHP is how, or whether, a CHP system works in conjunction with the local electricity grid. When a CHP system is linked to the grid, it is said to be 'interconnected' or operating 'in parallel' to the grid. When CHP systems operate completely independently of the grid, they are considered to be in 'grid-isolated,' 'standalone' or 'island' mode.

Virtually all buildings in New York City that deploy CHP operate in parallel mode, generating some portion of their electricity load on site and deriving the rest of their power from the grid. This is primarily because the high value of New York City real estate makes it too costly to build a CHP system large enough to meet all of a building's needs. For economic reasons, CHP systems are also usually sized to correspond with a building's heat needs, not its electricity requirements, as heat needs are generally lower.[58] Furthermore, in the absence of a grid interconnection, a backup generator would be required for unplanned outages or occasions when the CHP system is taken offline for regularly scheduled maintenance.

[54] National Renewable Energy Laboratory and the Gas Research Institute. *Gas-Fired Distributed Resource Energy Technology Characterizations.* Small Gas Turbine Systems. October 2003. pg. 3-23.
[55] Energy Nexus Group. *Technology Characterization: Microturbines*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002. pg. 22.
[56] National Renewable Energy Laboratory and the Gas Research Institute. *Gas-Fired Distributed Resource Energy Technology Characterizations.* Fuel Cell Systems. October 2003. pg. 5-24.
[57] Energy Nexus Group. *Introduction to CHP Catalog of Technologies*. Prepared for the Environmental Protection Agency Climate Protection Partnership Division, February 2002. pg. 11-12.
[58] Building a system capable of generating more thermal energy than the facility can use would violate the basic premise of CHP technology, which is to reduce the amount of energy wasted by the system.

The fact that local CHP systems interconnect to the Con Ed grid introduces three separate, but related, sets of issues.

1. ***The Fault Current problem*:** The Con Edison grid is designed with high levels of system reliability in mind. Multiple high voltage feeder lines deliver electricity to a substation, while neighborhood grids are fed by multiple feeders from different substations. This ensures that if there is a 'fault' (i.e. failure) at one point on this system, the substation or neighborhood grid still receives the power necessary to provide uninterrupted service to the community. Con Edison has also designed its electric distribution grid so that substation circuit breakers and 'network protector devices' isolate any problems that do arise, protecting crews working on the line and ensuring service on the balance of the network remains unaffected.

   Under normal operating conditions, electricity flows at a relatively constant and manageable level. When there is a problem on the network, the flow of electricity may spike,[59] triggering the substation circuit breaker and the network protector device, a type of technology which inhibits the backfeed of electricity into the grid. Because circuit breakers and network protectors halt the flow of electricity towards a fault on the line, they also allow Con Edison crews to safely resolve the problem.

   Interconnecting a CHP system into this grid configuration is a complex matter because it introduces a new, additional power source at a location where the grid was not originally designed to accept it. As a result, the possibility exists that – in the event of a fault on the network – the CHP system could send its power out of the building and back into the grid, adding to the level of fault current already present on the network. It is this additional flow of electrons potentially made available by the CHP system that concerns Con Edison most, as the cumulative amount of fault current may now exceed the rated capacity of the circuit breakers and network protectors to control the excess current, thereby allowing power to flow to the fault. This may energize a line thought to be dead, posing a safety risk to Con Edison repair crews and potentially damaging transformers and other equipment on the line.

   Given the relatively small number of distributed generation systems interconnected to the Con Edison grid, the risks of a malfunctioning circuit breaker and/or network protector device are generally remote, but they are significant enough for Con Edison to take every precaution to avoid them.[60] As a result, requests to interconnect CHP systems face rigorous scrutiny, particularly if they are large and/or are connecting to portions of the network that already handle other large distributed power systems.

2. ***Differences between Induction, Synchronous, and Inverter-based Generation*:** The risk that a CHP system will contribute to excess fault current is also a function of whether the system is operating inductively, synchronously, or in inverter-based mode. **Induction** generators cannot operate independently of the grid; in fact, the generator is triggered by a jolt of current from the grid, and the generator simply follows the frequency of this current while operating. If the connection to the grid is lost – such as would occur in a blackout – the generator shuts down automatically.

   Synchronous generators, on the other hand, can operate independently of the grid, as they have an autonomously powered 'exciter' that enables the generator to produce and regulate its own power. This capability has made synchronous CHP systems a popular choice in other parts of the country, as the system can provide backup power in the event of a blackout.[61] From the perspective of a local utility, however, this virtue can also be a liability,

[59] Electrons follow the path of least resistance; when there is a fault on the grid, electrons will naturally flow towards it, perceiving the fault to be a power vacuum waiting to be filled.
[60] Presentation by Dan Sammon, Manager – Distribution Engineering, Con Edison at Columbia University, March 1, 2007.
[61] It is important to note that even when a CHP system operates synchronously and can thus be used in the event of a blackout, most systems must first disconnect from the grid, shut down, and then restart in standalone mode – a process called a black start. Black start time can range from seconds to hours depending on the technology used. [See Appendix

as it increases the stray current risk to crews working to fix the problem that caused the blackout. It also exacerbates the fault current problem noted above. As a result, Con Edison has imposed very strict (and what some CHP system owners and developers call conservative) rules about synchronous interconnection. Such connections are not impossible, however. The synchronous connection of two 800 kW gas engines in the Equity Office building in midtown Manhattan in 2005 was the first such system connected to the midtown grid and was treated as a significant technological milestone by Con Edison.[62] [See case study in Appendix 3.]

Although from a technical perspective it operates completely differently, from a performance perspective **inverter-based** generation blends elements of synchronous and induction generation, in that its microprocessor-based controller allows the system to operate in parallel while still synchronizing its power with the grid. The controller can detect fault conditions on the grid and stop the system from producing power much faster than other forms of generation, thereby contributing insignificant levels of fault current to the grid.[63] Some types of inverters can also quickly and seamlessly switch a CHP system into grid-isolated mode, allowing the system to safely provide power to a facility during a grid failure without the risk of backfeed that can jeopardize the safety of work crews trying to fix the fault.

Currently, there are two types of CHP technologies that have integrated inverters: fuel cells and some brands of microturbines. However, inverters can be added to any type of CHP technology, and some reciprocating engine installations in New York City now use rectifier-inverters to increase power quality and facilitate the interconnection process.[64, 65]

The variability of fault current contribution levels between synchronous, induction, and inverter-based generation types can result in dramatically different experiences with the interconnection process. While systems with inverter-based and induction generators are comparatively easier to interconnect, systems with synchronous generators require a much more involved interconnection process, often including extra engineering feasibility studies[66] and an increased likelihood of project approval delays. Though selecting a type of generation involves consideration of issues such as project budget and type of CHP system technology, the decision is also strongly affected by fault current levels in the area of the grid where the CHP unit is to be interconnected.

3. ***Limits to Interconnected Distributed Generation Capacity:*** Regardless of the mode of generation, Con Edison imposes a 10 MW upper limit on the amount of distributed generation connected to distribution feeders, and a 20 MW limit for DG interconnected at the substation level.[67] Con Edison states that these limits represent the “maximum possible” levels of interconnected DG under ideal situations. This assumes that at area substations there are no additional limitations – such as fault current or other technical issues – that would restrict the amount of interconnected DG below these levels.[68]

1.] Some technologies using inverter-based generation, such as microturbines, are capable of seamlessly disconnecting from the grid and operating in island mode without the need for shutting down and black starting.

[62] Interview with Matt Vuolo, Regional Manager, Distributed Energy Systems (formerly Northern Power). April 20, 2007.

[63] Inverter-based generation relies on microprocessors to convert one form of electricity to another (such as DC to AC). Inverters can also improve the ‘quality’ of the power produced by a generation system by reducing voltage fluctuations, a situation which can be desirable in settings where highly sensitive electronic equipment may be damaged by small voltage changes (such as in hospitals).

[64] Con Edison. Distributed Generation - Inverted Generation. Accessed at http://q050-w5.coned.com/dg/configurations/inverted.asp on August 8, 2007.

[65] Communication with Clint Plummer, Vice President, Asset Development and Underwriting, Endurant Energy. August 8, 2007.

[66] Con Edison. Distributed Generation - Synchronous Generation. Accessed at http://q050-w5.coned.com/dg/configurations/synchronous.asp on September 7, 2007.

[67] Con Edison. *Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers*. March 2006. Accessed at http://m020-w5.coned.com/dg/specs_tariffs/EO-2115.pdf. pg. 14.

[68] Ibid.

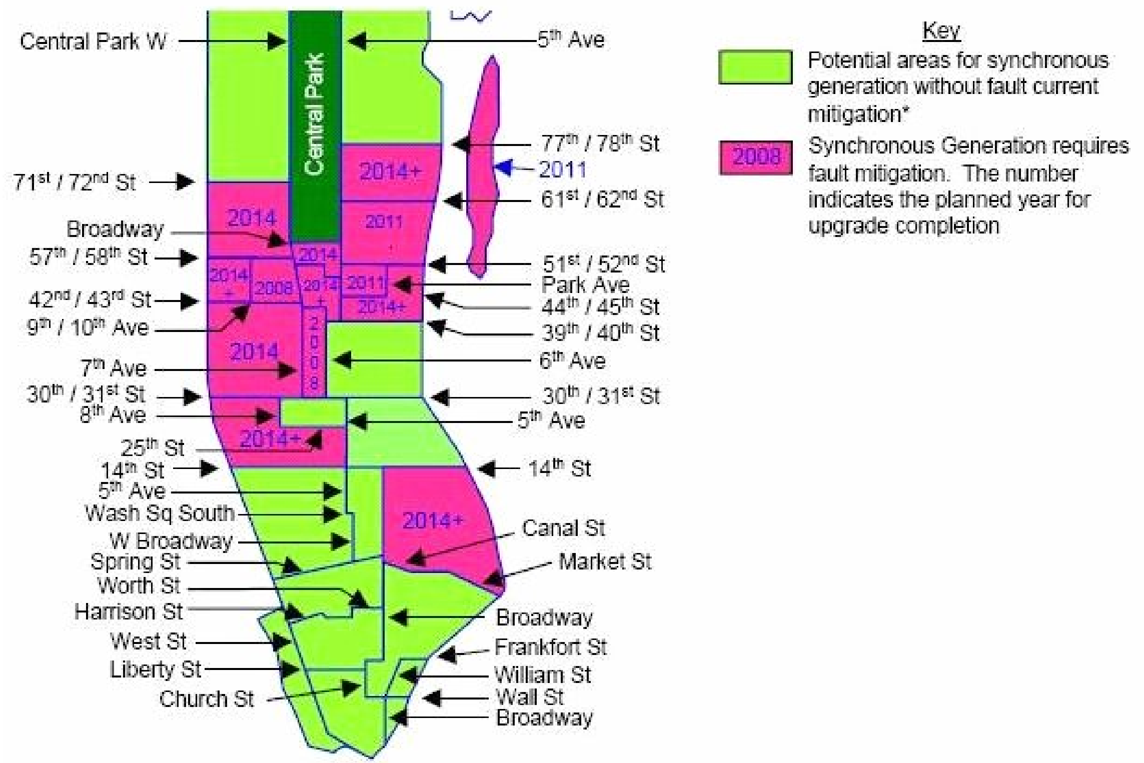
A 2005 fault current study commissioned by Con Edison at the behest of the PSC, discussed below, pointed out that Con Edison's method of calculating its limits for interconnected DG is different from that found in most industry guidelines. While Con Edison determines feeder limits based on the all-time *light* load, or lowest amount of power demand in that area of the grid, other utilities usually calculate limits based on a percentage of *peak* load within that part of the grid.[69] The study notes that Con Edison's existing 10 and 20 MW limitations effectively restrict distributed generation – which includes CHP – to a relatively small fraction of the peak load of feeders and substations.[70] Project developers must therefore ensure that these limits have not yet been reached within their respective area of the grid before pursuing the interconnection of a CHP project.

Overcoming the Fault Current Problem

In 2005, the PSC mandated a fault current review of Con Edison's grid, in order to obtain a better understanding of the technical issues posed by fault current and explore potential solutions to the problem. The study found that the redundant nature of the Con Edison grid design, while providing the highest levels of reliability in the country, simultaneously creates the conditions where fault current is a serious problem.[71] In the same order mandating the fault current study, Con Edison was also required to establish and publish a schedule for replacing all of its substation circuit breakers at their fault current limits with newer devices capable of handling higher levels of fault current.[72] Con Edison has complied with the PSC ruling, but due to the difficulty of scheduling the necessary equipment outages to replace the breakers – a result of Con Edison's grid redundancies, reliability requirements, and other outages for urgent repair work – the full replacement cycle is not scheduled to be completed until 2014.[73]

[69] Tim Taylor, Andrew Hanson, David Lubkeman, and Mirrasoul Mousavi. *Final Report: Fault Current Review Study.* Report No. 2005-11222-1-R.04, ABB Inc. Electric Systems Consulting. Submitted to Con Edison December 22, 2005. pg. 26.
[70] Ibid, pg. 24.
[71] Tim Taylor, Andrew Hanson, David Lubkeman, and Mirrasoul Mousavi. *Final Report: Fault Current Review Study.* Report No. 2005-11222-1-R.04, ABB Inc. Electric Systems Consulting. Submitted to Con Edison December 22, 2005. pg. 1.
[72] State of New York Public Service Commission, Case 04-E-0572. *Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York, Inc. for Electric Service*. Order Adopting Three-Year Rate Plan (issued March 24, 2005).
[73] Con Edison. *Synchronous Generation Placement Availability by Region* (website), accessed at http://m020-w5.coned.com/dg/configurations/maps.asp on July 20, 2007.

Figure 11
Con Edison Circuit Breaker Upgrade Map



Source: Con Edison. *Synchronous Generation Placement Availability by Region* (website), accessed at http://m020-w5.coned.com/dg/configurations/maps.asp on July 20, 2007.

Figure 11 is taken from a series of maps that Con Edison has developed showing which areas of New York City have available fault current margin (i.e., areas where more distributed resources can be added without exceeding the fault current limit) and the replacement schedule for areas with circuit breakers already at their fault current limit. In one sense, these maps serve as an early proxy of where certain types of interconnection projects – namely, those that involve synchronous generation – can be expected to face a longer and more complex review process. The maps also potentially serve as guides for where CHP promotion efforts could be targeted, either in general or for specific technologies. For example, Con Edison's website states that generation with inverters (microturbines and fuel cells) and induction generation may be installed at all locations on the map, regardless of fault current margin.[74]

A second technical solution external to the grid involves the use of power electronics, which are a mix of devices used to convert, control, and improve power quality. Previously, we have spoken of this technology in generic terms as the 'inverter' that can be integrated into the design of a CHP system. Inverters are required equipment on fuel cells because they produce DC current, which must be converted to AC before it can be consumed. Though microturbines produce AC current, some manufacturers use two complementary forms of power electronics – a rectifier[75]

[74] Con Edison, Map of Manhattan Synchronous Generation Placement Capability. Accessed at http://m020-w5.coned.com/dg/images/maps/m.pdf on August 8, 2007. Though the interconnection of inverter-based and induction generation systems still requires technical review by Con Edison, the duration and complexity of the review is likely to be substantially less than for synchronous interconnection. Con Edison also notes that inverter-based generation systems above 500 kW may require additional technical review. See Con Edison's discussion of inverted generation at http://q050-w5.coned.com/dg/configurations/inverted.asp.

[75] A rectifier converts AC power to DC power, while an inverter converts DC power to AC power.

and an inverter – to switch from AC to DC and back to AC power in order to produce higher quality power and facilitate interconnection. Power electronics technology facilitates the latter because the microchip processors can detect a problem on the grid and shut off or disconnect the CHP system from the grid within 1/240th of a second – fast enough to prevent any significant fault current contribution to the grid.[76]

Fault current limiters and power electronics will likely be an important part of the future CHP scene in New York City, because the fault current margin will always be linked to the total amount of electricity-generating capacity connected to the grid. As demand continues to increase each year around the city, requiring additional generation to be connected to the grid, the technological 'fixes' called for by the Public Service Commission will work for some time. At some point, however, the upgraded circuit breakers may also reach their higher-rated capacity limit, requiring yet another round of system upgrades.

Other Strategies to Facilitate CHP Deployment in New York City

Another solution that has drawn attention in other jurisdictions, in the US and beyond, is the microgrid: a small power distribution system that can link several distributed resources in a separate distribution system that allows all the connected sources to collectively operate either in parallel or independently from the grid. By aggregating and coordinating the output of multiple distributed power sources, microgrids provide a broader base of on-site generating capacity for connected users. Moreover, by presenting the grid with a single point of interconnection, they effectively allow multiple generating units to connect to the grid as easily as one unit. To the extent microgrids allow for redundancy by incorporating multiple power sources, microgrids also increase the likelihood that developers can sever their link to the grid altogether, operating completely in 'island' status.

While microgrids are a relatively established technology for military or university campuses,[77] more than ten years ago, a commuter town outside of London became home to one of the world's first municipal microgrids.[78] Thanks to the farsighted efforts of municipal energy services manager Allan Jones, the Woking town center – including civic offices, two hotels, a conference center, a bowling alley, and parking garage – produces enough power from CHP and photovoltaics to be completely self-sufficient for heat and power, with leftover power available for export to other areas via a microgrid. Jones' work attracted the attention of London Mayor Ken Livingstone, who appointed Jones as the first Director of his new London Climate Change Agency. Jones now has a mandate to "do a Woking" in London by increasing the city's use of microgrid-linked CHP and renewable power systems.[79]

It is easy to see the potential benefits of building microgrids in New York, with its highly constrained electricity grid and new targets for CHP and renewable power generation under the Mayor's *PlaNYC* initiative.[80] Con Edison reports they are exploring microgrid development in New York City, and it is expected to play a key role in the utility's "third-generation grid" plans (commonly referred to as 3G).[81] The time schedule for such changes is not yet clear.

[76] Communication with Clint Plummer, Vice President, Asset Development and Underwriting, Endurant Energy. August 8, 2007.
[77] David Engle. "CERTS Proves Two Grids Are Better Than One." *Distributed Energy*, March/April 2005.
[78] Paul Brown. "Woking shines in providing renewable energy." *The Guardian*, January 26, 2004.
[79] Hugh Muir. "Wake-up call from Woking." *The Guardian*, June 29, 2005.
[80] City of New York. *PlaNYC: A Greener, Greater New York*. Office of Long Term Planning and Sustainability, New York City Office of Operations. April 21, 2007.
[81] Presentation by Arthur Kressner, Director, Energy Delivery Research and Development, Con Edison at Columbia University. March 1, 2007.

Researchers at Columbia University are also examining what type of regulatory changes might facilitate the development of microgrids around the city.[82]

Technology Lessons for New York City

In New York City, CHP is an established technology for heat and power generation, and the benefits of small-scale CHP have already been realized among a variety of sectors and applications. The technologies discussed in this section portray multiple options for meeting electric and thermal demand across a range of sites, budgets, and emissions requirements. Despite this flexibility, however, the number of CHP installations in New York City remains well below potential levels. Although the balance of this report will discuss several other factors that contribute to low deployment levels, overcoming interconnection challenges – and particularly the fault current issue – are an essential aspect of increasing deployment of CHP systems in New York City.

The fault current problem is presently a fundamental fact of life given the nature of the Con Edison grid design. Nonetheless, there are several areas where City Hall can take action to help CHP projects better manage this issue.

First, the City should seek to understand where circuit breaker replacements fit into the utility's overall capital plan. The Public Service Commission gave Con Edison considerable latitude in establishing the deadline for when this work must be completed, but it is reasonable for the City to push to accelerate this work where possible. That said, it is also important for the City to examine its own permit approval processes (at the Department of Transportation and elsewhere) to ensure that Con Edison is not unduly delayed in gaining access to city streets to carry out this work.

Second, the City should work with Con Edison to develop more refined fault current maps that give system developers a better sense of which portions of each network grid are most problematic. As Figure 11 makes clear, some of Con Edison's networks cover scores or even hundreds of blocks, and it may be the case that it is only the feeders or substations in the southern or eastern quadrant of the network that have the greatest fault current problems. This information is relevant because it could help the City and CHP system developers better target their efforts to educate building owners about the benefits of CHP.

Detailed fault current maps could also be used to encourage developers to pursue CHP systems with inverted generation in areas with limited fault current margin. To the extent that inverter-based microturbine or fuel cell CHP technologies can be used at a site – or that inverters or other power electronics devices can be included in other CHP system technologies – project developers may be able to bypass the technical challenges posed by fault current. For this reason, one developer expressed the view that the use of power electronics such as inverters are the "key to interconnection" in the future. Similarly, PSC-mandated fault current study specifically recommends that Con Edison "encourage DG developers to evaluate the use of [inverters] for DG interconnections to the grid" as one mechanism for limiting fault current to minimal levels.[83]

Since system size needs and budget limitations do not always permit the use of inverted generation systems, other technological fixes for fault current mitigation are necessary. As fault current limiters or various forms of power electronics become a more common component of new CHP installations, the City may also wish to consider ways to provide some financial relief to

[82] For more information, contact Dr. Stephen Hammer, Director, CEMTPP Urban Energy Program at sh2185@columbia.edu.
[83] Tim Taylor, Andrew Hanson, David Lubkeman, and Mirrasoul Mousavi. *Final Report: Fault Current Review Study.* Report No. 2005-11222-1-R.04, ABB Inc. Electric Systems Consulting. Submitted to Con Edison December 22, 2005. pg. 3.

system developers opting to use this equipment. Particularly in areas where circuit breaker replacements are years away, these technological add-ons may be the best or cheapest option to help expedite interconnection approval from Con Edison. What is key is the difference in who bears the cost for the different technological fixes. The New York State Public Service Commission forced Con Edison to establish and implement a circuit breaker upgrade program; the cost for this work is borne by Con Edison, which then passes the cost onto ratepayers all over the city. FCLs and power electronics, on the other hand, are a cost borne entirely by a CHP project developer. In those situations where Con Edison system upgrades might eventually obviate the need for such equipment, it may be reasonable to provide some type of cost relief to the developer for these projects.

The City should further explore how Con Edison's 10 and 20 MW feeder and substation limits for interconnected DG would potentially change if these limits were instead calculated as a percentage of peak load. Though the fault current review study states that using this alternative calculation method may not necessarily result in a quantitative change in the limit, the study does point out that Con Edison's current method restricts levels of interconnected DG to a small fraction of peak load. It would be of benefit to the City to understand the opportunities for increased levels of interconnected CHP that might stem from changing the method of calculating feeder and substation limits.

Finally, it behooves the City to monitor efforts focused on microgrid development in other cities. To the extent this technological approach appears capable of ameliorating local interconnection problems, it would clearly help in the city's efforts to attain 800 MW of CHP deployment by 2030.

Recommendations

Recommendation #1*: The City of New York should work with Con Edison to examine ways to accelerate the pace of circuit breaker upgrades on the network. This includes fostering collaboration between Con Edison and relevant City agencies to ensure that Con Edison receives any necessary permit approvals to carry out this work in a timely manner.*

Recommendation #2*: The City of New York should work with Con Edison and the NYS Public Service Commission to develop more refined maps detailing the extent of the fault current problem within individual network grids. These maps should indicate the different technological options for fault current mitigation available within specific areas, including inverted generation and fault current limiters. This information should then be used in targeted education and outreach efforts promoting CHP deployment among building owners around New York City.*

Recommendation #3*: The New York City Economic Development Corporation should work with NYSERDA and the NYS Public Service Commission to examine whether investments in fault current limiters or power electronics by CHP system developers should be entitled to some type of financial relief from the utility or other entity to help offset the additional cost of these devices.*

Recommendation #4*: The City of New York should work with Con Edison and the NYS Public Service Commission to examine how the 10/20 MW limits for interconnected DG might change if these limits were instead calculated as a percentage of peak demand, as is the practice commonly followed by other utilities. The results of this study should be used to select the method of calculating interconnected DG limits with the greatest potential for increasing levels of CHP deployment in New York City.*

Section 3: The Policy and Regulatory Environment for CHP in New York City

As a general characterization, the policy environment for CHP in New York City is a mixed bag. There are several policies in place – established at all levels of government and within the energy marketplace – that specifically seek to incentivize CHP deployment. On the other hand, many local firms seeking to install CHP systems view the current regulatory and permitting schema as quite *unfriendly* towards CHP, arguing that various permitting processes lack transparency and subject installation projects to unnecessary, budget-busting technical or operating requirements. In the case of one CHP technology, for a period of time the permitting process reached such a roadblock that local developers contemplated abandoning efforts to deploy these systems altogether.

In this section we discuss the various ways that federal, state, local, and utility policies impact the local CHP market. Some information is presented simply for contextual reasons, while in other cases this information highlights specific actions the New York City Economic Development Corporation's Energy Department could take to advance CHP system deployment around New York City.

Federal Policies Towards CHP – A Focus on Reducing the Cost of Local CHP System Deployment

Federal policy towards CHP is primarily limited to tax policy mechanisms that reduce the cost of individual installations. The most relevant tax credit was established by the Energy Policy Act of 2005; it offers developers or system owners a one-time business tax credit equal to 10% of the cost of a microturbine installation. This credit applies *only* to microturbine technology, and the value of the credit is linked to the actual cost of the system itself. Project design, engineering or other costs (e.g., permitting) cannot be included when calculating the value of the credit. As a tax credit, this policy provides immediate value to the project developer/owner, directly reducing the amount of business tax owed. The federal CHP tax credit is currently authorized through December 31, 2008, and it is not clear whether it will be reauthorized past that date, or whether – if reauthorized – it could be expanded to cover other types of CHP technologies.

New York State CHP Policies – Facilitating Deployment While Safeguarding Public Health

Through its energy, environmental, and regulatory agencies, the State of New York plays an active role in the local CHP picture. It is safe to say that absent state-level involvement, local deployment levels would be much lower, and individual projects would face an even murkier approval process than they currently do.

- *Financial Subsidies to Support CHP and Expand Local Awareness of this Technology*

NYSERDA is the key agency responsible for promoting CHP deployment around the state. Through their support of CHP research and development and installation-specific incentive programs, NYSERDA has profoundly improved the deployment prospects for this technology sector.

NYSERDA support for CHP projects is funneled through a variety of programs that target energy savings, energy efficiency or environmental improvements, but the primary mechanism is through the Distributed Generation and Combined Heat & Power (DG-CHP) program.[84] On an annual basis, this program provides $15 million in direct subsidy support to CHP projects around the state. In New York City, 45 small-scale CHP projects representing nearly 38 MW of nameplate capacity have received approximately $23.3 million in NYSERDA support since 2001. The average project has received subsidies totaling $519,000, while on a per kilowatt basis, the average project has received subsidies totaling $615/kW.[85]

Like all NYSERDA funding programs, the DG-CHP program is time-limited, with a predetermined budget. Thus far, NYSERDA has renewed its CHP program several times, although there have been substantial changes along the way with each new funding round. Project developers must therefore closely monitor program deadlines to ensure they do not miss out on funding due to changing eligibility guidelines. The various CHP-related Program Opportunity Notices (PONs) currently available from NYSERDA are listed in Appendix 5.

- *Public Health and Environmental Rulemaking*

The environmental and public health aspects of local CHP deployment fall under the purview of the New York State Department of Environmental Conservation (DEC). Their primary concern is with the air emissions of a proposed CHP installation. Because New York City is considered a moderate non-attainment area for particulate matter (PM) and carbon monoxide (CO), and a severe non-attainment zone for oxides of nitrogen (NOx) and volatile organic compounds (VOCs),[86] state officials monitor whether new CHP plants will exacerbate the region's long-standing air quality problems.

The air quality permit approval process and emissions limit thresholds are spelled out in the guidelines of the Uniform Procedures Act (UPA) of Article 70 of the New York State Environmental Conservation Law.[87] The UPA lists the steps and time frames for 1) determining the adequacy of permit applications; 2) seeking public involvement; 3) resolving outstanding issues; 4) making final decisions on permit applications; and 5) managing appeals of Department decisions. Ultimately, the duration and complexity of the air quality permitting process is contingent on the size of the CHP installation, and whether total projected emissions[88] will surpass the levels allowed for New York City. [See Table 1]

[84] See http://www.nyserda.org/programs/dgchp.asp.
[85] Source: Extrapolated from data provided by Mark Torpey, CHP Program Manager, NYSERDA. Note: these figures do not reflect a $1 million grant to New York University for a 15 MW CHP project, because that project exceeds our 10 MW "small scale" project designation.
[86] New York State Department of Environmental Conservation. *Air Pollution Control Permit Program: Is This Project Major or Minor?* (website) accessed at http://www.dec.ny.gov/permits/6244.html on August 2, 2007. As required by federal Clean Air Act guidelines, the US Environmental Protection Agency (EPA) monitors local air quality to gauge compliance with six key "criteria pollutants," including carbon monoxide, sulfur dioxide, lead, nitrous dioxide, ozone, and particulate matter.
[87] New York State Department of Environmental Conservation, *Uniform Procedures Act (UPA)*. Accessed at http://www.dec.ny.gov/permits/6230.html on July 10, 2007.
[88] State rules focus on the total quantity of emissions from a facility. To the extent a CHP system is installed as a supplement to other systems in the building that also have air emissions, it is the cumulative total that is DEC's primary concern – the existing emissions plus the incremental addition of emissions attributable to the new CHP system.

Table 1
Air Pollutant Threshold Levels Applicable to CHP Projects in New York City

Pollutant	Minor source (in tons/year)		Major Source (in tons/year)
Volatile Organic Compounds	<12.5	12.5 - 25	>25
Hazardous Air Pollutants (any single one)	<5	5 – 10	>10
Hazardous Air Pollutants (cumulative)	<12.5	12.5 - 25	>25
Nitrogen Oxide (NO_x)	<12.5	12.5 - 25	>25
Particulate Matter ≤ 10 microns (PM-10)	<50	50 - 100	>100

Source: Extrapolated from NYSERDA, *Combined Heat and Power Market Potential for New York State (Final Report 02-12)*, October 2002. pg. 8-9 . Also, telephone interview with Harry Ching, P.E., Project Manager, New York State Environmental Facilities Corporation Small Business Assistance Program. July 13, 2007.

Facilities with emission levels higher than the Major Source threshold must obtain a *Title V Permit*, which local CHP system developers report can involve hundreds of thousands of dollars in upfront engineering, consulting, and legal fees. These costs are in addition to a $1250 permitting fee.[89] After the permit is issued, the facility must pay an annual fee to DEC, which is levied according to the amount of regulated pollutants the source emits each year. [90] Facilities with emission levels falling below this threshold qualify as "minor" sources, for which there are two permitting categories.

- Facilities with emission thresholds exceeding 50% of the Major Source threshold must obtain a *State Facilities Permit*. In general it takes up to 120 days[91] to obtain this permit, with a permitting fee of $1250.[92]
- Facilities with emission thresholds less then 50% of the Major Source threshold are required to obtain a *Minor Facilities Registration*. Registration is usually a one-time process, although renewal can be necessary.[93] According to state guidelines, DEC must issue these permits within thirty days from the date the application is received, at a set cost of $200, making this a much simpler, faster, and cheaper process than that faced by systems with higher emission levels.[94]

In a limited number of cases – such as a CHP system involving an internal combustion engine rated at 200-hp or less that is powered by natural gas or diesel fuel – the CHP system may be categorized as an *Exempt and Trivial Activity*, meaning no state permit or registration is required.[95]

[89] New York State Executive Budget, Transportation, Economic Development and Environmental Conservation, Article VII Legislation, Part L. S.6559/A.9559, January 21, 2004.
[90] Title V annual fees are either $1250 or an amount not exceeding $45/ton of contaminant up to 6000 tons, whichever is greater.
[91] New York State Environmental Facilities Corporation. *Clean Air News for Small Business*, Volume 4, Issue 1, Fall/Winter 1999. pg. 3. Accessed at http://sbap.nysefc.org/docs/fall-1999.pdf on July 30, 2007.
[92] For municipalities or other not-for-profit corporations seeking a State Facilities Permit, registration, or other operating approval, the flat fee is $100. 2004-2005 New York State Executive Budget, Transportation, Economic Development and Environmental Conservation, Article VII Legislation, Part L. S.6559/A.9559, January 21, 2004; entered into full force on April 1, 2004.
[93] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002. pg. 8-12.
[94] New York State DEC, *Subpart 201-3: Exemptions and Trivial Activities* (website), §201-3.2(3)(i) Exempt activities. Accessed at www.dec.ny.gov/regs/4303.html on July 30, 2007.
[95] Ibid, accessed on July 13, 2007.

Aside from the length of time and cost involved in pursing air quality permits, the primary concern levied by project developers is that this process fails to adequately account for the fundamental emission benefits offered by CHP systems. This criticism was noted in NYSERDA's 2002 CHP assessment[96] and echoed by developers interviewed for this report. Specifically, the NYSERDA report noted that air quality regulations are "based on limiting the emission of criteria pollutants per unit of fuel input, or their concentration in exhaust streams from specific sources."[97] Although CHP and separate heat and power systems may have the same amount of emissions per unit of fuel *input*, the higher efficiency of the CHP system means they have a lower emission level per unit of energy *output* when compared to other power plants and thermal systems. As a result, the permitting process essentially undervalues their overall emission benefits, potentially subjecting the systems to a more rigorous permitting process than is appropriate.[98] This is particularly relevant to CHP projects in New York City, given its non-attainment status for criteria air pollutants.[99]

Box 2

How will RGGI affect the prospects for CHP deployment in NYC?

The Regional Greenhouse Gas Initiative (RGGI) is an agreement among ten Mid-Atlantic and Northeastern states to reduce greenhouse gas emissions from large local power plants. New York State played a significant leadership role in promoting the development of this multi-state agreement. Under the terms of RGGI, which comes into effect in 2009, all power plants exceeding 25 MW in size that derive the majority of their energy from fossil fuels are subject to RGGI's CO_2 emission limits. The RGGI mandates may raise the price of electricity generated by power plants exceeding these caps, making small-scale CHP systems more cost-effective when compared to grid-based sources. For more information about RGGI, go to www.rggi.org.

New York City's CHP Policy – A Bump in the Road for One Technology, but Steady Progress Overall

In their 2004 report, Mayor Bloomberg's Energy Policy Task Force endorsed the use of CHP as one distributed resource strategy that might help alleviate the city's looming energy supply shortfall.[100] The Task Force report did not specify any fixed numerical deployment target, or announce any concrete policy proposals designed to promote greater levels of CHP deployment around the city. The New York City Economic Development Corporation's Energy Department did make headway in this regard in the 2005 regulatory proceeding considering Con Edison's request for a rate increase. In that process, EDC successfully negotiated an agreement whereby Con Edison would examine the role that distributed resources (like CHP) could play in local "load pockets" and areas of the city where significant new development was expected to occur.[101]

In December 2006, the City took yet another step forward, passing Local Law 1, which requires the Department of Citywide Administrative Services to conduct a CHP viability assessment of all City facilities that are large (≥500 kW peak demand) energy users.[102] The assessment must be completed by January 2008.

[96] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002. pg. 8-13.
[97] Ibid pg. 8-8.
[98] Ibid pg. 8-15.
[99] New York State Department of Environmental Conservation. *Air Pollution Control Permit Program: Is This Project Major or Minor?* (website) accessed at http://www.dec.ny.gov/permits/6244.html on August 2, 2007.
[100] New York City Energy Policy Task Force. *New York City Energy Policy: An Electricity Resource Roadmap.* January 2004.
[101] New York City Energy Policy Task Force. *2004 Status Report*. Accessed at http://www.nycedc.com/NR/rdonlyres/96D076FA-8D0F-4AA7-B7F4-1B1330614BAD/0/EPTF2004StatusReport.pdf on July 30, 2007.
[102] New York City Council. *Local Laws of the City of New York for the Year 2007-- No. 1: A Local Law to amend the administrative code of the city of New York, in relation to an assessment of city facilities regarding certain clean on-site power generation technologies*. Passed by the Council on January 3, 2007; signed by the Mayor on January 17, 2007.

The April 2007 release of *PlaNYC: A Greener, Greater New York* heralds the most significant commitment to CHP technology by the City, establishing firm deployment targets and several key policy commitments intended to drive action by Con Edison, private developers, and City agencies.

Key CHP initiatives called for in *PlaNYC* include:[103]

- Establishment of a citywide target of no less than 800 MW of CHP deployment by 2030.
- Acknowledgement of deficiencies in the current permitting and interconnection review process, and a commitment to working with key stakeholders (including City agencies) to address these issues.
- Announcement of intention to use Con Edison's 2007 tariff increase filing to pressure the utility to study how more distributed generation can be accommodated on individual network grids. The City also announced its intention to push Con Edison to develop an on-line tracking system informing CHP system developers where their interconnection applications are in the approval pipeline, and notifying them when delays occur.
- Announcement that the Mayor's office has urged Con Edison to conduct a more detailed review of CHP system viability at the Hudson Yards development site in Manhattan, and a commitment to "seek to implement a district energy plan through Con Edison or independent developers" if it appears feasible.
- Announcement of intention to amend the New York City building code to require large new developments (>350,000 square feet) to analyze the technical and economic feasibility of establishing CHP on-site.

Unmentioned, but perhaps implicit in *PlaNYC*'s acknowledgement that City government agencies bear some responsibility for delays in CHP system deployment, are concerns associated with the use of microturbine CHP technology. This problem became pronounced in 2005,[104] triggered by the New York City Fire Department's (FDNY) refusal to sign off on construction permit applications authorizing the use of the high pressure gas lines required by these systems.

The FDNY was reportedly not comfortable with the presence of high-pressure natural gas in buildings, citing the risk of fire and explosion.[105] High pressure gas is essential for microturbines to function, however, as the turbine generates power both from the mechanical energy provided by high-pressure gas entering the combustion chamber and from the combustion process itself. The FDNY placed a number of siting and operational restrictions on microturbine systems, such as requiring 50-foot clearances from dwellings and the presence of a Certificate of Fitness holder[106] on site while the unit is operating.[107] These requirements were so stringent that – by one engineer's estimation – 95% of all microturbine projects proposed in the city would be uneconomic.

The Certificate of Fitness holder requirement was considered particularly onerous because microturbine units are designed to operate constantly, suffering sharp decreases in efficiency when operated only part-time. However, in many office buildings and smaller businesses, staff are not present after normal work hours. Neither option – paying employees to be on-site to "watch the microturbine" nor shutting down base-loaded systems when the building is vacant – was considered to be an economically viable alternative.

[103] City of New York. *PlaNYC: A Greener, Greater New York.* Office of Long-Term Planning and Sustainability, New York Office of Operations. April 21, 2007.
[104] Matthew Scheuerman. "Developers say they can't build green." *New York Observer*, April 8, 2007.
[105] Note: The FDNY would not accept requests for interviews to discuss this matter.
[106] A Certificate of Fitness holder is an individual certified by the FDNY to operate and/or shut down certain types of equipment deemed hazardous.
[107] Interview with Deborah Taylor, Executive Director, New York City Department of Buildings. June 7, 2007.

CHP system developers argued that New York City was unique in imposing such stringent requirements, pointing to the fact that other cities around the world allow high-pressure gas lines in buildings without objection from their local Fire Department. Moreover, they note that the latest microturbine models have now fully integrated the componentry deemed most problematic by FDNY into the turbine body itself, passing the Underwriters Laboratory (UL) testing standard[108] along the way. Finally, developers insisted there were many safety redundancies in the equipment, including automatic shut-off features that limited any danger of explosion.[109] Despite these claims, the issue has remained unresolved for 2½ years, frustrating microturbine installers and customers alike.

One non-profit telecommunications company interviewed as part of our research noted that their inability to deploy their microturbine system created a huge financial hardship for the firm. The owner commented that, "We were trying to do the right thing by installing an energy-efficient technology, but almost a million dollars' worth of equipment was just sitting here." A consultant to one of the City's largest real estate development firms suggested that if this situation was not successfully resolved soon, she would advise the company to abandon future efforts to deploy CHP technology in its New York City-based projects.

This situation has been made all the more ironic by the fact that microturbine technology is the only CHP technology currently eligible for federal business tax credits, a factor that likely has something to do with the growing interest in this technology.

In an effort to resolve this issue, the New York City Department of Buildings, the FDNY, and other key stakeholders convened a Cogeneration Task Force in 2006. Their objective was to find a way to regulate microturbines, simultaneously addressing concerns about safety and marketing feasibility. This process is nearing a conclusion – culminating in an addition to City rules relating specifically to microturbines – which balances the interests of the various stakeholders involved. Though the new "microturbine rule" has not yet been released for public comment, its expected adoption should allow proposed and existing microturbine installations to again be economically feasible.[110]

Con Edison & CHP – Balancing Competing Interests

As the local distribution network operator in New York City, the task facing Con Edison on a daily basis is unquestionably a challenging one. By law, the company must provide safe and reliable electric distribution service to any household or business located in New York City.[111] Failure to comply with this requirement potentially subjects the utility to fines from the PSC. Con Edison also has other important obligations, however – to protect the safety of its workers, and to protect the long-term fiduciary interests of Con Edison shareholders by managing the grid in a way that does not adversely affect its future revenue potential.

Seen through these lenses, Con Edison's cautious approach regarding interconnection issues makes a great deal of sense. It is unreasonable to allow a single customer seeking to install on-site power generation to jeopardize the quality of service Con Ed provides to the rest of its

[108] Equipment passing a UL testing standard at a nationally-recognized testing lab essentially receives the equivalent of an outside auditor's warranty that the technology operates as designed in a safe manner. Several models of microturbines have passed the UL 2200 testing standard, which is not specific to microturbines, but is applicable to equipment models of stationary engine generator assemblies. Source: interview with Deborah Taylor, Executive Director, New York Department of Buildings, June 7, 2007; and Underwriters Laboratories Inc., *Scope for UL 2200*, accessed at http://ulstandardsinfonet.ul.com/scopes/scopes.asp?fn=2200.html on July 10, 2007.

[109] New York City Department of Buildings, Report of Materials and Equipment Acceptance Division. Materials and Equipment Acceptance 193-05-E, 2005.

[110] Communication with Deborah Taylor, Executive Director, New York Department of Buildings, September 7, 2007.

[111] New York State Public Service Commission. *Case 90-E-1119 (Proceeding on motion of the Commission to consider establishing standards on Reliability and Quality of Electric Service) -- Order Adopting Standards on Reliability and Quality of Electric Service (Issued and Effective July 2, 1991)*

customer base. To that end, Con Edison explicitly states on its website that "Con Edison permits any customer to operate generating equipment in parallel with the company's electric system, *provided there is no adverse effect on the company's other customers, equipment, or personnel, or the quality of service*."[112] [emphasis added]

On the other hand, it is also important to consider whether Con Edison's efforts at safeguarding the grid have become excessive, to the detriment of other important energy-related goals held by the City of New York or others.

Over the past few years, Con Edison has published two reports that hint at a favorable view towards CHP, without actually embracing it. For example, in 2005 Con Edison completed an *Energy Infrastructure Master Plan* for portions of Manhattan.[113] In that report, Con Ed concluded that distributed generation (such as CHP) could defer required electricity infrastructure upgrades in certain neighborhoods by 2-4 years, forestalling millions of dollars in system investment.[114] That same year, Con Edison published a *System Reliability Assurance Study* comparing the benefits of alternative investments aimed at delivering enhanced grid system reliability. Reciprocating engine CHP systems were identified as one of the most cost effective technologies, capable of delivering enhanced reliability benefits at a price far lower than investments in large new central station power plants or repowered central station facilities.[115] Interviews conducted with Con Edison staff for this report further highlighted their view that CHP will have an important role to play in their "3G System of the Future" project.

This backdrop provides interesting context in which to view Con Edison's interconnection policies. Several CHP system developers interviewed for this report claim that Con Ed actively uses this policy control power to delay or discourage CHP interconnections. Such views are hardly unique to New York City – several years ago a national study reported that utilities are regularly accused of interconnection-unfriendly practices designed to protect their core revenue base.[116, 117]

The basis for much of the local discontent is a perceived lack of transparency and predictability in Con Edison's interconnection approval process, which is described at length in *Specification EO-2115 (Handbook of General Requirements for Electrical Service to Dispersed Generation Customers).*[118] By order of the PSC, Specification EO-2115 details the Standardized Interconnection Requirements (SIR),[119] an 11-step process outlining the data submission requirements faced by distributed generation project applicants and the timeframe and data response obligations Con Edison must abide by in return.

Although the SIR was only intended to apply to systems rated <2 MW, in 2005 Con Edison agreed to follow the same 11-step SIR process when dealing with applications for larger CHP

[112] Con Edison. *Distributed Generation* (website). Accessed at http://m020-w5.coned.com/dg/default.asp on July 5, 2007.
[113] The EIMP for Hudson Yards/Lower Manhattan was commissioned by the Public Service Commission as a condition of Con Edison's request for a tariff increase in 2005.
[114] Con Edison. *Energy Infrastructure Master Plans--Hudson Yards and Lower Manhattan*. Revised December 2, 2005. Pg. 32
[115] Con Edison. *System Reliability Assurance Study*. December 30, 2005. pg. 47
[116] Brent Alderfer, Monika Eldridge, and Thomas Starrs. *Making Connections – Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects*. National Renewable Energy Laboratory, May 2000.
[117] In the wake of market restructuring efforts, many utilities operate solely as distribution network operators, deriving their revenues from power distribution sales. Because on-site power generation decreases a building's need for grid-based power, policies that discourage CHP interconnections are one way of protecting a utility's revenue base. In *PlaNYC*, the City of New York may have acknowledged this as being a potential problem when it endorsed efforts to try to separate Con Edison's profits from the amount of energy used in the city. See City of New York. *PlaNYC: A Greener, Greater New York.* Office of Long-Term Planning and Sustainability, New York City Office of Operations. April 21, 2007. pg. 106
[118] Con Edison. *Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers*, March 2006. Accessed at http://m020-w5.coned.com/dg/specs_tariffs/EO-2115.pdf.
[119] New York State Public Service Commission. *New York State Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems*. September 2005.

systems rated 2-5 MW in capacity.[120] Arguing that these projects involve a more cumbersome review, Con Edison gave itself more flexibility when responding to applications for any system installation exceeding 2 MW in size.[121]

At the heart of every interconnection application process is a Coordinated Electric System Interconnection Review, or CESIR. It is here that Con Edison identifies what impact the customer's proposed CHP system would have on local fault current levels, and determines what – if any – technical fixes are required to prevent any degradation of existing service quality or hazard to Con Edison staff. The SIR, under PSC rule, requires that the cost of this analysis and any necessary system upgrades are borne by the project developer, because these represent costs Con Edison "would not have incurred but for the interconnection of the [CHP system]."[122]

Especially in the case of large installations, these costs can be quite significant, totaling hundreds of thousands or even millions of dollars. The CESIR is thus specifically designed to provide an early estimate of what these costs might be, allowing applicants to withdraw their application if it appears these additional costs will threaten the overall economic viability of the project.

From the perspective of developers and institutions seeking to install CHP systems around the city, the ambiguity inherent in a process involving such loose deadlines has huge budget implications. It is difficult to forecast the amount of engineering or legal support required if one can't predict how long the process will take, or whether Con Ed will come back with repeated requests for more information. Favorable project financing deals may also disappear if the project can't obtain approval within the timeframe established by a bank. One CHP system developer expressed tremendous frustration over their dealings with Con Edison, suggesting the interconnection review process is the equivalent of 'a bureaucratic trainwreck,' replete with unanticipated delays and contradictory guidance from different Con Edison business units. Others offered a far kinder assessment, noting the 'reasonableness' of Con Edison engineers and the fact that local project timetables were not significantly different from what has been seen on projects outside of New York City.

State SIR rules require Con Edison to log all applications, milestones met, and justifications for application-specific requirements.[123] PSC staff regularly monitor this information and are available to help resolve problems that arise on individual installations. PSC staff report that they actually field "very few" customer complaints about interconnection issues, and that problems often appear to result from communication failures on the part of both entities.[124] Another point emphasized by PSC staff is that much of the feedback they receive about utility interconnection decisions is anecdotal, and that it is hard to assign fault or remedy problems in the absence of documentary evidence from complainants. Finally, PSC staff emphasized there is no avoiding the fact that Con Edison operates a highly complex network grid, and part of the problem may be that it's simply harder to interconnect systems in New York City than in other cities.

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[120] Interview with Michael Worden, Chief, Distribution Systems & Generation, New York State Public Service Commission. July 11, 2007.
[121] For example, under the SIR, Step 4 (Con Edison shall conduct a preliminary review and develop a cost estimate for the Coordinated Electric System Interconnection Review) involves a 5-day turnaround requirement for systems <2 MW. Systems 2-5 MW are subject to much less restrictive timeframes, with Con Edison noting that their response time "may be longer than 15 days due to the added complexity of the system impacts associated with larger installations." Source: Con Edison, *Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers*. March 2006. pg. 39-40.
[122] Con Edison. *Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers*, March 2006. pg. 36
[123] New York State Public Service Commission. *New York State Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems*. September 2005. pg. 1
[124] Interview with Michael Worden, Chief, Distribution Systems & Generation, New York State Public Service Commission. July 11, 2007.

Muddling Through?

What are we to make of this complex policy and regulatory environment? There are several points worth highlighting.

First, federal and state policies have clearly been supportive of CHP deployment. Given the dynamic nature of federal and state incentive programs, however, the City should remain vigilant in monitoring these programs and lend its vocal support to those initiatives it wishes to see reauthorized.

In the case of the state air quality permitting process, there was little evidence to date that state policies are actively inhibiting CHP projects, although it may be true that projects are enduring a more rigorous (and costly) permitting process than is necessary.

The City's own policymaking efforts appear increasingly CHP-friendly. The Fire Department's concerns over high pressure gas lines clearly had an adverse effect on microturbine CHP technology, but that issue appears to be moving towards resolution and should allow the vast majority of these projects to finally move forward.

Passing judgment on Con Edison policies and procedures for interconnections is a far more vexing matter. It is unclear how much of the interconnection problem is a learning curve, rather than a process-based problem. There are currently fewer than 140 CHP systems interconnected to the local grid, most of which have been installed over the past ten years. As Con Edison engineers and project developers gain additional experience installing and working with these systems, the process may become faster and more predictable.[125] Technological advances being pursued by Con Edison to overcome fault current limits[126] may also lead to a faster interconnection review process. Regardless, the situation on the ground would likely improve if there were a local CHP 'ombudsman' available to help negotiate a resolution of any problems with Con Edison, or more systematically monitor how well Con Ed is fulfilling its obligations under the SIR. This office/individual could also share this information with the state Public Service Commission on a regular basis, enhancing the PSC's ability to oversee Con Ed compliance on these issues.

The City's plan to pressure Con Edison to develop an internet-based tracking system that clarifies where projects are in the approval pipeline is another worthwhile idea. It will be important to follow the progress of this initiative to ensure this system is developed and that it meets the planning needs of the CHP development community.

One thing to consider is that the current interconnection policy environment may be more or less problematic depending on how the local CHP market matures. It is clear that larger systems currently face a more complex interconnection review process, meaning that if these systems gain popularity, then pressure may build to fundamentally reform the process so it is more transparent/predictable. By contrast, if smaller systems predominate, there may be less need to reform the process because interconnection approvals for these systems are already easier/faster to obtain.

Paradoxically, there is a completely different way to look at this same market maturation issue. If larger (e.g. 5+ MW) systems predominate, the current Con Ed process may actually suffice, as we are unlikely to see more than a handful of CHP projects proposed each year. If very small scale systems predominate, however, then Con Edison's ability to respond to all of the project

[125] There is already evidence this is occurring. Between EO-2115 (Revision 7) and EO-2115 (Revision 8), Con Edison reduced the response times they commit to following in Step 6 of the SIR review process.
[126] See the discussion beginning on page 17.

applications in a timely manner will be sorely tested.[127] NYSERDA's 2002 study on CHP deployment in New York implies that CHP projects in the Con Edison service territory will tend to be relatively small. Recall from Footnote 28 in Section 2 that the 'average' commercial and office sector CHP projects will be in the 230-360 kW range. At this size, the demands placed on Con Edison's interconnection review and approval process each year could become substantial, meaning close oversight by the City and the Public Service Commission will be necessary to ensure projects keep moving apace.

Finally, it is important to keep in mind that the local interconnection policy environment may ultimately be overwhelmed by fundamental electricity market changes that create new incentives for Con Edison to facilitate interconnections. One example is New York City's quest to achieve "rate decoupling" – the disaggregation of Con Edison's profits from the amount of electricity that it distributes to local users. If interconnection levels were to become a new metric on which Con Edison's profits were partly based, the utility would have a profound incentive to overcome many of the technical barriers currently inhibiting CHP deployment. A second significant market change could occur in the area of microgrid development. Microgrids essentially operate on the principle that if the old grid is unaccommodating of distributed generation or other forms of 'smart technology', then the problems of the old grid can be averted by simply overlaying a more advanced grid system atop the old one.

Microgrids are currently the focus of considerable discussion in London (England) and Stamford (Connecticut), and research is currently underway at Columbia University's Center for Energy, Marine Transportation and Public Policy that will shed more light on how microgrid systems might be established in New York City.[128]

[127] The Mayor's *PlaNYC* report calls for 800 MW of CHP in New York City by 2030. Since there are already approximately 118 MW of small scale CHP deployed around the city, to attain this target another 100-120 5+ MW systems must be deployed over the next 23 years. This averages just five projects per year, something well within the current staffing capabilities of Con Edison. If projects tend to be much smaller (e.g. <200kW), however, Con Edison could be required to respond to hundreds of applications each year. Add to this an increase in the number of solar PV interconnections called for by *PlaNYC*, and the situation could quickly become unmanageable.

[128] For more information, contact Dr. Stephen A. Hammer, Director, CEMTPP Urban Energy Program at sh2185@columbia.edu.

Recommendations

Recommendation #5*: The City of New York should work with the New York City Congressional delegation to advocate for an extension and possible expansion of the federal CHP business tax credit program.*

Recommendation #6*: The NYC Economic Development Corporation and Department of Buildings should establish a mechanism to more systematically educate local developers of large new building projects about NYSERDA CHP-funding opportunities. EDC should also work with NYSERDA to develop funding programs specifically designed to support education and outreach programs targeting the local industrial sector as well as real estate developers and managers in New York City.*

Recommendation #7*: The New York City Economic Development Corporation should work with NYSERDA and the New York State Department of Environmental Conservation to examine current emissions regulations to determine how the review process can more accurately account for the emissions benefits delivered by CHP.*

Recommendation #8*: Once the Cogeneration Task Force has completed its work in resolving FDNY safety concerns with microturbines, the NYC Economic Development Corporation should collaborate with the NYC Department of Buildings to host a workshop educating building owners/managers and other key stakeholders on how the issue was resolved. This information should also be posted on the EDC website.*

Recommendation #9*: The NYC Economic Development Corporation should seek the collaboration of a range of key local stakeholders in developing the specifications for an on-line portal tracking the status of CHP interconnection applications at Con Edison.*

Recommendation #10*: The NYC Economic Development Corporation should fund the development of a "DG Ombudsman" position responsible for helping to resolve CHP system installation problems in New York City.*

Recommendation #11: *The NYC Economic Development Corporation should meet with Con Edison to discuss their interconnection review staffing plans to ensure the utility is taking all steps necessary to support a potentially dramatic increase in interconnection applications.*

Section 4: The Economics of CHP in New York City

Although facility owners may pursue CHP for several reasons – such as an interest in climate protection or enhanced on-site energy security – at the end of the day, most projects will only be realized if they deliver energy services at a cost equal to or lower than existing grid-based sources. The price of CHP system-generated power reflects both ongoing fuel and maintenance costs, as well as the amortized capital and soft costs associated with the design, purchase, and installation of the system. Each of these is influenced in some way by the basic CHP technology choice, local energy prices, and the broader policy and regulatory environment.

In this section, we discuss how these factors can influence costs at the individual project level. Since determining a CHP system's economic viability can be a convoluted process, we have structured this section as a sequence of the key decision points at which this viability must be assessed and reassessed. [See Figure 12] Unfortunately, there is no database which identifies projects that have been abandoned for economic reasons. Such a list would have been helpful in allowing us to identify which factors have the greatest influence on individual project decisions. As will become clear, many of the policy recommendations made in Section 3 could have an impact on several of these key economic factors. This section concludes by highlighting additional steps New York City officials could take to improve the economic landscape for local CHP installations.

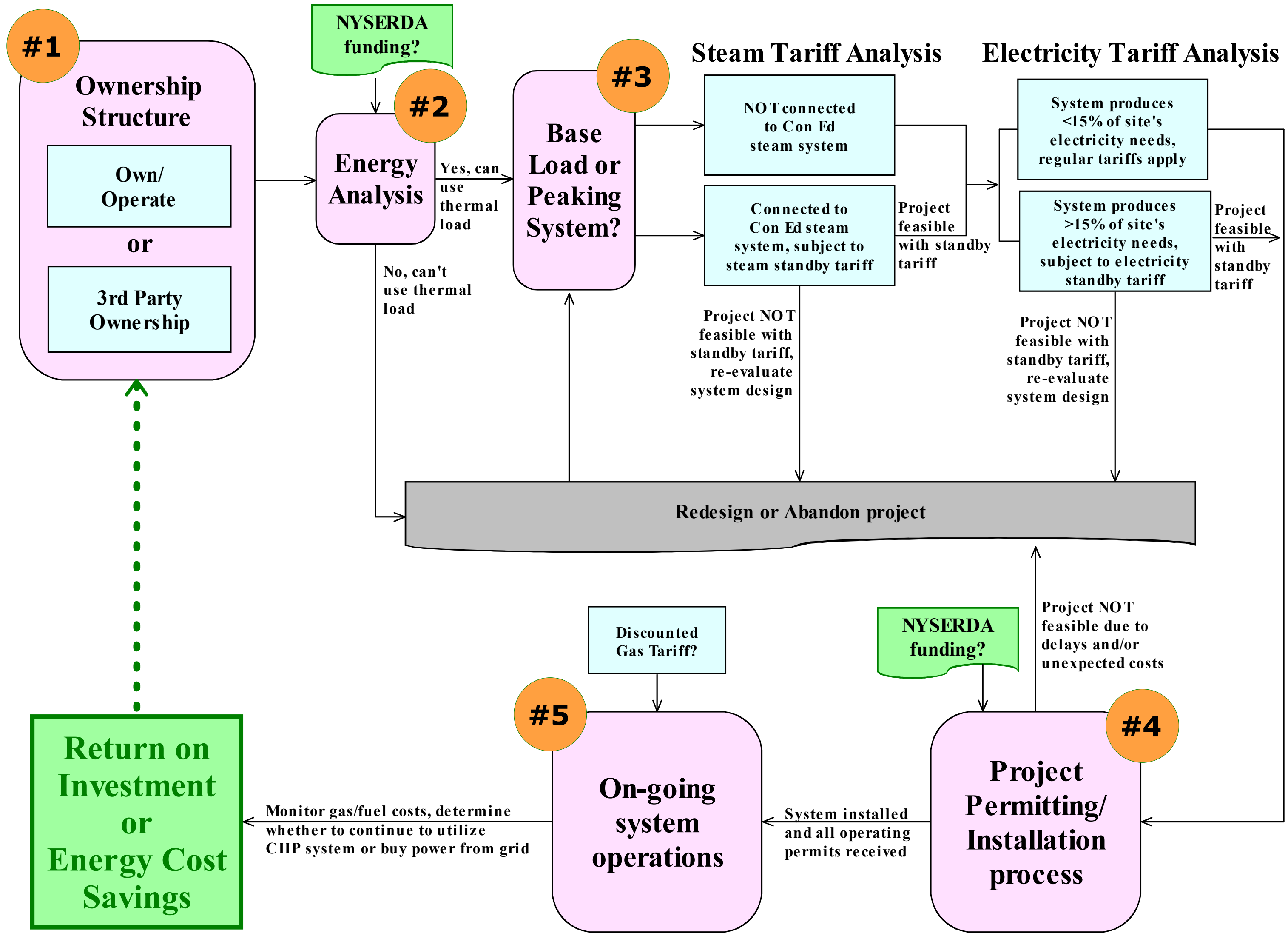
Key Factors Influencing CHP Project Costs

Key Economic Factor #1 – CHP system ownership model. The decision to own and operate a CHP system is not to be taken lightly, given the high up-front cost and complex technologies involved. Once the value of a CHP system has been documented, those considering whether to pursue a CHP system must also assess different system ownership models, each of which has their own advantages.

Fundamental to this decision is the site owner's willingness and/or financial ability to cover the costs of the system, and the availability of on-site technical staff to operate and maintain the equipment. Owners of a CHP system also assume all of the risks associated with ownership—such as rising fuel prices, equipment problems, and project delays/budget overruns. Facilities with the wherewithal to own and operate a system that choose to do so will tend to accrue the greatest return on investment, however, as any savings revert directly back to their bottom line.

In situations where the technical capacity of the site staff is inadequate, the site owner does not wish to operate and monitor the CHP system, or the user is unwilling or unable to cover the capital costs of the equipment, there are alternative ownership models that allow a facility owner to outsource these responsibilities. There are three standard third-party ownership models available for firms interested in the benefits of CHP without the hassles of ownership. Some of these are managed by traditional energy service companies (ESCOs) while others are arranged by engineering firms specializing in CHP installations or the CHP system manufacturers themselves.

Figure 12
CHP Economic Decision Schema: Key Factors Affecting the Economic Viability of CHP Projects
Source: Based on original research by Jeanene Mitchell and Stephen Hammer



- *Power purchase agreement (PPA) model*. Under the PPA model, a third party installs, owns, and operates a CHP system at a site and sells electricity and/or heat to the facility owner over an extended (10+ years) period of time. Under this model, all up-front and ongoing operating costs are borne by the third party; this entity also seeks out (and retains) any subsidies or tax credit for which the project is eligible. The project developer then converts the project's total cost stream into a per kilowatt-hour price, which the building owner agrees to pay for the duration of the contract period.[129] In general, the contracted rate will be a fraction of a cent less than the price of purchasing electricity from the grid. Although the PPA model exists in the New York City market, and interest in it is growing, PPAs are not widespread. CHP project developers interviewed for this report believe this is because many office and multifamily buildings in New York City simply pass all energy costs on to their tenants, meaning they have little incentive to change their current energy practices.

- *Lease and Energy Services Agreement (LESA).* This is a variation of the PPA model, insofar as a third-party owns and operates the CHP system on behalf of the building owner. The key difference is that the third-party/ESCO simultaneously agrees to pay rent to the building owner for the space occupied by the CHP system. Since a LESA creates an additional revenue stream for the building owner, it also incentivizes them to pursue CHP projects, thus overcoming the energy cost pass-through problem noted above. The LESA model can be expected to provide energy to the building owner on terms slightly less favorable than a straight PPA, reflecting the additional rent cost incurred by the ESCO/system owner.

- *Joint-ownership model*. This model combines private ownership and a LESA agreement through the creation of a joint debt- and equity-financed limited liability corporation established between the third party/ESCO and site owner. The ESCO installs, operates, and maintains the CHP system at the site while allowing the site owners to benefit from the energy savings in proportion to the amount of equity they invest. This model will provide greater savings to the site owner than a normal power purchase agreement because they also earn a portion of the third-party/ESCO's profits. We are unaware of any specific instances where this approach has been used in New York City, although local CHP system developers report it has been discussed with several potential customers.

Key Economic Factor #2 – The adequacy of demand for a CHP system's thermal output. CHP is predicated on capturing the economic value of waste heat generated by some type of energy conversion process, so determining the electric and thermal profile of a site is an important first step in any CHP system viability analysis. CHP systems are best suited to sites with high electric and thermal demand year-round, so in general, the greater the demand for the heat produced by the CHP system, the better the economic outcome of the project. In New York City, funding assistance is available from NYSERDA to help building owners assess the energy needs of their facility and how CHP can fit into this picture.[130]

Key Economic Factor #3 – The System Design/Tariff Structure nexus. Section 2 of this report detailed several key differences in the way CHP technologies operate, including space requirements, their noise and emissions profile, and their maintenance requirements. Building owners may prefer one technology over another based on these criteria. One other critically important factor is the decision of whether the unit will be operating as a "base load" or "peaking" system. Base load systems run on a 24/7 basis, meeting the basic energy requirements of the building. Peaking systems operate during specific intervals, such as when electricity demand is

[129] These prices will normally be written in a way such that they include some type of annual inflator and/or a mechanism that adjusts the price when natural gas or other feedstock costs change.
[130] Technical assistance grants are currently available through NYSERDA PON 1047. The deadline for applications is November 30, 2007. See http://www.nyserda.org/funding/funding.asp?i=2 for more information.

highest or electricity is most expensive.[131]

Sites with base-loaded systems will often employ different technologies than sites with peaking systems. For example, microturbine systems are most cost-effective when they operate 100% of the time. Internal combustion engines and fuel cells – while they can be base-loaded as well – are better technology choices if the CHP system is intended only to reduce peak demand charges due to their scalability and higher variable costs. [See Table 2]

Table 2
Comparison of Selected CHP Technology Costs[132]

Type of technology	Capital cost ($/kW)	Fixed O&M cost ($/kW-year)	Variable O&M cost ($/MWh)
Microturbine CHP	$2,650.00	$33.00	$3.00
IC engine CHP	$1,420.00	$3.30	$17.50
Molten Carbonate fuel cell CHP	$8,600.00	$7.00	$42.00

Source: Con Edison, System Reliability Assurance Study, 12/30/05, p 36

As a result, the most cost-effective system depends on the behavior of the CHP system user. Sites which have relatively constant thermal and electric demand throughout the year are good candidates for base-loaded CHP, while commercial and residential sites are more likely to have peaking systems to reduce electricity and thermal demand during certain parts of the day.

The decision to design the system as a base-load or peaking generator will simultaneously be influenced by the tariff structure(s) the facility pays for various forms of energy. Table 3 below summarizes the relevant utility tariff structures when pursuing CHP projects.

– *Steam*: In Manhattan, buildings served by the Con Edison steam system[133] will find that if their CHP system fails to replace 100% of the thermal load currently served by the steam system, they will be required to pay a supplemental steam tariff – known as *Service Classification No. 4* – for Con Ed steam they do consume.[134]

  Normal customer rates for the various steam service classifications vary by level of consumption and, in some cases, by season. Customers must pay a monthly service charge.[135] The supplementary steam service tariff, however, also includes a significant Contract Demand Charge per 1000 pounds of steam per hour, based on the customer's total contracted steam demand for each month.[136] This is in addition to consumption-based rates and monthly service charges.

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[131] Peaking systems exploit the fact that commercial and industrial customers pay electricity rates partly based on their highest level of consumption during the month. Power produced by CHP systems thus can reduce – or 'shave' – peak demand levels for that business, thus reducing that portion of the facility's monthly electricity bill.

[132] In this analysis, Con Edison compiled generic national estimates of the cost of CHP technology and then multiplied these figures by a "New York City" cost factor that reflects the higher cost of doing business locally.

[133] The Con Edison steam system provides heating, cooling, and hot water services to approximately 1,800 customers in Manhattan, including many large customers such as the United Nations complex, the Metropolitan Museum of Art, and the Empire State Building.

[134] Specifically, the steam tariff provisions state that supplementary tariffs apply to customers "who utilize both steam supplied by [Con Edison's] steam system for any purpose and another energy source for the same purpose." Consolidated Edison Company of New York, Inc. *P.S.C. No. 3 – Steam. Service Classification No. 4: Back-up/Supplementary Service. Sixth Revised Leaf No. 20-A, issued December 7, 2000*. Accessed at http://www.coned.com/documents/steam/Rates.pdf on July 19, 2007.

[135] Consolidated Edison Company of New York, Inc. *P.S.C. No. 3 – Steam. Service Classification No. 4: Back-up/Supplementary Service. Fifth Revised Leaf No. 23, issued August 25, 2005*. Accessed at http://www.coned.com/documents/steam/Rates.pdf on July 19, 2007.

[136] Ibid.

- *Electricity:* Any New York City building interconnected to the grid whose CHP system supplies 15% or more of their total electricity demand will be shifted to a more expensive standby tariff class known as *Service Classification No. 14-RA*, which includes an extensive system of standby electric rates and monthly customer charges.[137] These rates and charges differ depending on the "Otherwise Applicable Rate" – what the customer's tariff class would be had they not pursued the CHP system.[138] With few exceptions, the site's electricity delivery charges are billed at this higher standby rate. Customers which do not produce 15% or more of demand on-site, or whose total contracted demand is less than 50kW, are not subject to SC 14-RA, though they may be required to pay interconnection charges.[139]

- *Gas*: In contrast to steam and electricity, gas tariffs have improved for some CHP customers, thanks to a 2003 mandate by the New York State Public Service Commission intended to facilitate greater deployment of distributed generation technologies. The *Rider H* gas tariff applies to commercial customers under Service Classifications 2 and 9, and is conditional upon maintaining a certain level of gas demand.[140] The tariff varies according to the size of the CHP system – with systems above 5 MW receiving the most favorable rates. The tariff includes a minimum monthly charge and varying seasonal charges for gas consumption in excess of 3 therms.[141]

Table 3
Summary of CHP-Related Utility Tariffs

Tariff Type	Name	Key Differences from Normal Tariff Structures
Steam	Service Classification 4: Back-up/Supplementary Service	• Applies to any customer replacing steam demand with on-site thermal production • Includes Contract Demand Charge per 1000 pounds of steam demand per hour ($870 for on-peak users; $655 for exclusively off-peak customers)
Electricity	Service Classification 14-RA: Standby Service	• Applies to customers producing >15% of total electricity demand on-site • Rate varies based on original tariff class
Gas	Rider H	• Applies to commercial customers under SC 2 and SC 9 • Minimum monthly charge and gas rate vary with CHP system size

Facilities considering CHP system deployment must thus look at both short and long-term costs under different system size scenarios, as there may be tremendous benefit to increasing the size of the system to reduce the need for supplementary energy from Con Edison. In cases where space or budget constraints make it difficult to do so, the project may be abandoned as uneconomic.

[137] Consolidated Edison Company of New York, Inc. *P.S.C. No. 2 – Retail Access. Service Classification No. 14-RA – Continued: Standby Service. Sixth Revised Leaf No. 144, issued March 31, 2005*. Accessed at http://www.coned.com/documents/ra/ra-sc14.pdf on July 19, 2007.
[138] Consolidated Edison Company of New York, Inc. *P.S.C. No. 2 – Retail Access. Service Classification No. 14-RA – Continued: Standby Service. Second Revised Leaf No. 173, issued April 28, 2006*. Accessed at http://www.coned.com/documents/ra/ra-sc14.pdf on July 19, 2007.
[139] Consolidated Edison Company of New York, Inc. *P.S.C. No. 2 – Retail Access. Service Classification No. 14-RA – Continued: Standby Service. Fourth Revised Leaf No. 174, issued October 31, 2006*. Accessed at http://www.coned.com/documents/ra/ra-sc14.pdf on July 19, 2007.
[140] Consolidated Edison Company of New York, Inc. *P.S.C. No. 9. Section VI. Service Classification Riders, Continued: Rider H. First Revised Leaf No. 154.8, effective January 1, 2004*. Accessed at http://www.coned.com/documents/gas_tariff/pdf/0003(06)-General_Information.pdf#page=37 on July 19, 2007.
[141] Ibid.

Within the CHP development community, there is widespread concern that the current tariff structure has rendered otherwise-solid projects economically unviable.[142] Con Edison counters by arguing that these tariff structures are necessary to allow the company to supply CHP users with their required electricity/steam load when these systems are not operating. Because the Public Service Commission approves all tariffs, they can only be changed during a formal rate case proceeding.[143]

Key Economic Factor #4 – Project Development Costs. It is difficult to generalize the development costs for CHP projects due to their wide variability and site-specific nature. The technology and policy sections provided a lengthy explanation of why this is so, particularly in the area of interconnection-related costs. Interconnection requirements imposed by Con Edison can result in additional engineering studies and new componentry not included in the original project budgets. Permitting process delays can cause projects to lose favorable financing terms. These circumstances collectively add up to a situation where prospective CHP system owners and developers must tread warily when estimating their project budgets, particularly on larger installations.

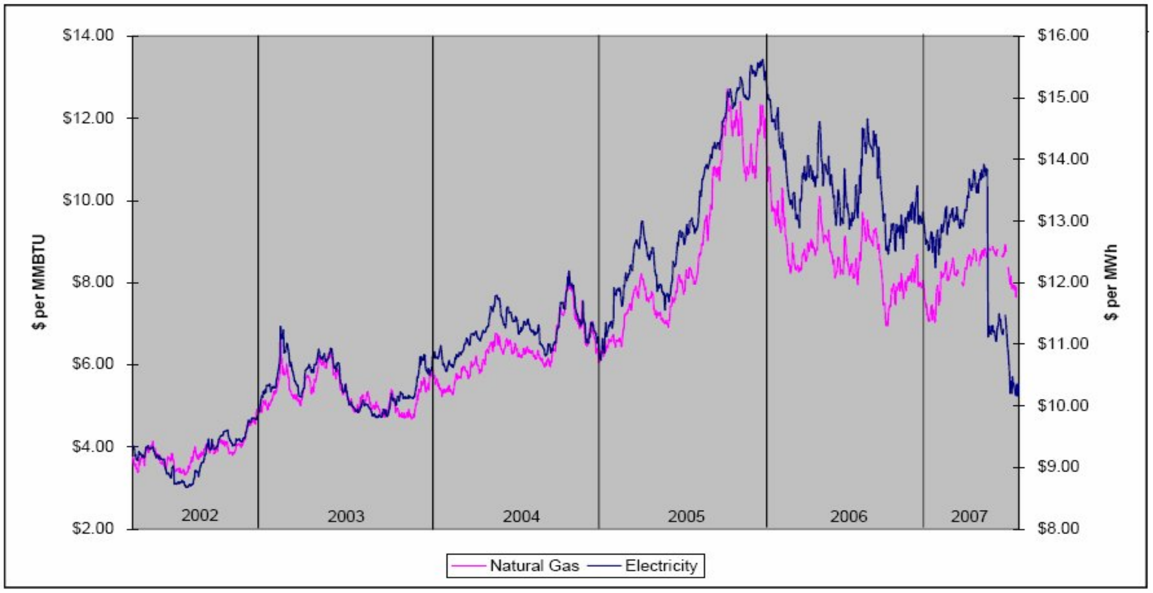
Key Economic Factor #5 – Operating Costs. The costs of grid-based electricity, steam, and natural gas service all affect the long-term cost effectiveness of a CHP project. New York Presbyterian Hospital's interest in pursuing a CHP project was a direct result of rising electricity prices in 2004-2005.[144] Similarly, the high cost of Con Ed steam was a major driver behind the New Yorker Hotel's decision to install a CHP system at their facility.[145]

Since New York State energy markets were fully restructured in 2001 there has been a gradual upward trend in statewide electricity and steam prices. This trend appears to be closely correlated with the rising wholesale price of natural gas in the region. Figure 13 shows New York City-specific electricity and gas price data for the period 2003-2005.

Since fuel costs comprise a large component of the cost of on-site electricity, high gas prices can at times make CHP more costly than purchasing from the grid. If this occurs, the CHP system may be temporarily turned off, with electricity being purchased from the grid during this time. The threshold is known as the "spark spread" – the difference between the cost of purchasing electricity from the grid and the cost of purchasing fuel for operating a CHP system. A larger positive spark spread increases the economic viability of a CHP project.

[142] New York State Energy Research and Development Authority. *Combined Heat and Power Market Potential for New York State (Final Report 02-12)*. October 2002. pg. 8-18.
[143] On May 4, 2007, Con Edison filed a request with the state Public Service Commission for an increase in local electricity tariffs. See Case # 07-E-0523. Con Edison is also in the final stages of Case #03-G-1671, a request for increases in its natural gas rates. Con Edison steam tariffs were last changed in Case 03-S-1672, which was approved by the Public Service Commission in September 2004.
[144] Presentation by Jennifer Kearney, Energy Manager, New York Presbyterian Hospital, at Columbia University. February 1, 2007.
[145] Interview with Joseph Kinney, Senior Project Engineer, New Yorker Hotel. June 7, 2007.

Figure 13
Wholesale Natural Gas and Electricity Prices in New York City (2002-2007)[146, 147]



In the course of our research, several CHP system owners and developers indicated that they closely monitor fuel costs, deciding on almost a daily basis whether it is more cost effective to generate power or purchase it from the grid. As gas prices have escalated in New York, spark spreads have become smaller, particularly for those eligible for industrial electricity rates. One local developer suggested that recent high natural gas prices are leading system owners to turn off their gas-fired CHP installations more frequently than originally intended. This problem provides one of the best arguments for a building owner to obtain their CHP system through a power purchase agreement, because the responsibility for monitoring and addressing gas price fluctuations generally falls on the system owner/operator.

Policy Lessons from the CHP Economic Decision Schema

Policymakers can help facilitate increased CHP deployment in New York City by exerting their influence at several points along the CHP economic decision schema. The initial feasibility study can be critical in showing skeptical building owners the financial benefits of a CHP system, so expanding the level of financial and technical assistance for these studies may increase deployment levels. NYSERDA has been very helpful in supporting feasibility studies, but given current limits on the level of statewide funding, it may be unreasonable to expect New York City projects to gain a bigger share of this money. The City's *PlaNYC* announcement that it will seek to establish a separate pool of funds for local energy projects[148] may be one mechanism to expand or supplement NYSERDA monies. Funding could similarly be used to educate building owners about the benefits of CHP and help them think through the advantages of different system ownership models.

The tariff question is a difficult one for City officials, as this issue falls under the direct purview of the New York State Public Service Commission. The PSC is unlikely to reverse course and

[146] Source: Communication with Clint Plummer, Vice President, Asset Development and Underwriting, Endurant Energy. August 8, 2007.
[147] These prices reflect peak hour prices for NYISO Zone J wholesale electricity and wholesale Transco Zone 6 gas rates.
[148] City of New York. *PlaNYC: A Greener, Greater New York.* Office of Long-Term Planning and Sustainability, New York Office of Operations. April 21, 2007. pg. 103

significantly lower the standby tariffs for electricity or steam service any time soon. The gas tariff, on the other hand, is an excellent vehicle for aiding CHP projects, to the extent that most systems will rely on natural gas as their fuel source. The gas tariff may not completely overcome price rises attributable to standby steam or electricity tariffs – particularly if the CHP system is undersized due to space constraints – but its greatest advantage is that it can be specifically structured to influence CHP market development efforts. As a result, this is one area where the City should focus its advocacy efforts at the state level. The EDC should also examine other opportunities to partner with Con Edison and Keyspan on special natural gas incentive rate programs targeting CHP system owners, thus providing some relief to the trend of increasing natural gas prices.[149]

The issue of transparency and timeliness of the interconnection and review process was already discussed at length in the earlier policy section of this report, and any recommendations highlighted there were done so because of the economic benefits that would result.

Recommendations

Recommendation #12*: If the City receives approval to establish its own independent financing mechanism for local energy projects, the New York City Economic Development Corporation should allocate a portion of the funds to supplement existing NYSERDA monies available for CHP viability assessment studies.*

Recommendation #13*: The NYC Economic Development Corporation should work with the Public Service Commission to examine the extent to which standby tariffs penalize CHP operations in New York City. As part of this analysis the City and State can examine ways to enhance the use of natural gas tariffs as an incentive for expanding CHP system use around the city.*

[149] Con Edison already cooperates with the City of New York on a Business Incentive Rate for electricity services, offering a discount on the rate they charge for the delivery of electricity service.

Section 5: Conclusion

Combined heat and power technologies can play a significant role in helping New York City address its impending in-city electricity supply shortfall in a more sustainable manner. The growing number of small-scale installations around the city – 40% of which have been deployed in the past five years alone – testify to the value of CHP's greater efficiency and money-saving potential. With the Regional Greenhouse Gas Initiative (RGGI) coming into effect in 2009, bringing with it the prospect of higher electricity prices for central generation-based power, CHP may become an even more attractive option for meeting New York City's electric and thermal needs.

Despite the benefits of CHP, there are many opportunities for projects to become sidetracked in New York City. As this report repeatedly noted, interconnection is a major hurdle, and other issues – from air permitting to fluctuations in gas prices – have the potential to inhibit deployment as well. Given that current small-scale CHP deployment levels represent just 118 MW of generation capacity[150] – despite nearly 3,200 MW of aggregate CHP deployment potential within Con Edison's service territory[151] – ***PlaNYC*'s goal of 800 MW of CHP by 2030 must be seen as rather optimistic, absent a CHP policy paradigm shift.** Over the next several years, until fault current limiters enter the market, overduty circuit breakers at feeders and substations are replaced, and the use of power electronics becomes commonplace, there will likely not be a significant increase in overall CHP deployment levels around New York City. Longer-term prospects, however, are contingent on policy changes made in the near future. Laying CHP-friendly policy groundwork now will allow CHP deployment to increase rapidly once technological upgrades are in place. Achieving the Mayor's goal should therefore follow a two-track approach, in which the City works with state officials and key market stakeholders to improve both the short and long-term outlook for CHP technologies.

As a first step, we believe that a local 'CHP Partnership' should be established to provide overarching direction and support to any CHP market development effort, operating under the auspices of the City's Economic Development Corporation. This public-private partnership, consisting of local and state government officials, utility representatives, and other key energy sector and environmental/community stakeholders, could harness the knowledge and financial resources necessary to tackle the most pressing issues impeding CHP deployment.

As part of its short-term strategy, the New York City CHP Partnership should focus on evaluating the interconnection process currently in place. Local policymakers and Con Edison would both benefit from an independent assessment of such issues, as it should clarify the extent to which interconnection difficulties must remain an unavoidable fact of life in New York City. The Partnership would be well-positioned to guide this assessment and interpret its findings.

Since the 2005 PSC-mandated fault current review of Con Edison's grid was only a narrow examination of technical issues, it never explored how well the overall interconnection review process works.[152] The focus of any interconnection review should therefore begin with the process itself – including a determination of how well the existing application and notification procedures function, and the appropriateness of various approval timelines. An interconnection review may find Con Edison's timetable quite appropriate, given the complexity of the grid and the site-specific engineering analysis that Con Edison must perform for every application; it may also

[150] Including CHP systems larger than 10 MW, there is 218 MW of installed CHP capacity. This figure includes the 109 MW system at JFK airport and the 37 MW system at Amalgamated Warbasse Houses in Brooklyn.
[151] New York State Energy Research and Development Authority. *CHP Market Potential for New York State (Final Report 02-12)*, October 2002. pg A-4.
[152] Tim Taylor, Andrew Hanson, David Lubkeman, and Mirrasoul Mousavi, ABB Inc. Electric Systems Consulting. *Final Report: Fault Current Review Study.* Report No. 2005-11222-1-R.04. Submitted to Con Edison December 22, 2005.

find that alternative decision rules or a larger in-house engineering review team dedicated to distributed generation projects could cut the current project approval time in half.

Some of the local qualitative data needed to undertake this evaluation could come from a new EDC-based 'DG Ombudsman' who could provide insight into where the interconnection process has created challenges for local project developers and site owners. The online interconnection application tracking system proposed by *PlaNYC* could also generate useful data for the evaluation, while simultaneously allowing CHP project developers to see where their project is in the approval process. The monitoring of this system could be included as part of the ombudsman's responsibilities, in order to ensure that the system is meeting developers' needs.

Secondly, the CHP Partnership's review should include an examination of the technical 'fixes' called for by Con Edison, to see if the requirements imposed as a condition for interconnection are excessively cautious or appropriate given the need to maintain high levels of system reliability. The CHP Partnership should also examine the EO-2115 guidelines' stipulation that no more than 10-20 MW of distributed generation can be installed on any individual network feeder or substation. It is important to understand the logic undergirding these limits, as these caps represent the final word on how much interconnected DG we can ultimately expect to see in New York City. Such an analysis may take time to complete, requiring actual performance data from CHP projects currently installed around the city. To the extent the Partnership can facilitate its collection, field data regarding local CHP system reliability and performance may aid Con Edison's assessment of whether it can relax current guidelines.

In carrying out its tasks, the Partnership should bear in mind that micro-CHP will inevitably find its way to New York City, vastly increasing the number of CHP units seeking to interconnect to the electric grid. Although we did not examine micro-CHP at length in this report, our discussion in Appendix 4 gives the reader some background on how the technology works and its prospects for deployment in New York City. Should there be high household demand for micro-CHP units in the medium term, Con Edison could face a crushing administrative and technical burden, slowing interconnection determinations to a crawl.

The CHP Partnership must also keep in mind that current interconnection issues may be more of a 'learning curve' problem than a process or technology problem. Over time, as Con Edison engineers and project developers continue to gain experience in installing and interconnecting CHP systems, the interconnection process may well become more predictable and less technically problematic.[153] The microturbine issue that is the current focus of the City's Cogeneration Task Force is informative in this regard. Although not an interconnection problem, this group has been wrestling with the fundamental question of how to satisfy various stakeholder concerns relating to the deployment of microturbine technology. We will soon know how successful the Task Force has been in addressing these concerns and allowing deployment of this technology to move forward. To the extent the CHP Partnership can learn from the Cogeneration Task Force's negotiation and technology review process, we believe it will play a helpful role in pushing local stakeholders further along this interconnection 'learning curve.'[154]

As a longer term strategy, we believe the Economic Development Corporation and the CHP Partnership should conduct research into new market structures and regulatory systems – such as rate decoupling – that more systematically incentivize CHP interconnections with the local grid. The *PlaNYC* report already announced the Mayor's interest in this subject, and much work must be done to explore how to change the local regulatory schema so it more explicitly rewards Con

[153] There is already evidence this is occurring. Between EO-2115 (Revision 7) and EO-2115 (Revision 8), Con Edison reduced the response times they commit to following in Step 6 of the SIR review process.

[154] At the time of this writing, the forthcoming "microturbine rule" was not yet available for public comment. As a result, we were unable to reflect on how the Task Force ultimately balanced the interests of the various stakeholders involved. Once the microturbine rule is issued, an addendum to this report will be posted on the CEMTPP website.

Edison for facilitating CHP and other DG deployment. Rules promoting microgrid development could also help build demand for CHP technology, as these units would serve as the heart of microgrid energy systems. To the extent there are other long-term market-building opportunities available, the CHP Partnership would be well-positioned to identify and act on them. Researchers at Columbia and elsewhere are already tackling these issues, and their work could be a jumping-off point for Partnership efforts.

As an ever-growing center of global commerce, industry and culture, New York City's burgeoning energy demand shows no sign of abating. While there is a clear role for CHP to play in filling the supply gap, CHP's potential will only be realized to the extent that a pro-CHP policy environment can be implemented within New York City. The varied scope and nature of the recommendations above demonstrate that removing the roadblocks to CHP deployment is an involved process involving multiple stakeholders. Though there is no simple solution to making CHP 'plug and play,' beginning this process now can strengthen medium- and long-term prospects for this technology, helping to meet or even exceed the Mayor's 800 MW target while making New York City a world leader in urban CHP deployment.

Summary of Recommendations

***Recommendation #1**: The City of New York should work with Con Edison to examine ways to accelerate the pace of network protector device upgrades on the network. This includes fostering collaboration between Con Edison and various City agencies to ensure that Con Edison receives all necessary permit approvals to carry out this work in a timely manner.*

***Recommendation #2**: The City of New York should work with Con Edison and the NYS Public Service Commission to develop more refined maps detailing the extent of the fault current problem within individual network grids. These maps should indicate the different technological options for fault current mitigation available within specific areas, including inverted generation and fault current limiters. This information should then be used in targeted education and outreach efforts promoting CHP deployment among building owners around New York City.*

***Recommendation #3**: The New York City Economic Development Corporation should work with NYSERDA and the NYS Public Service Commission to examine whether investments in fault current limiters or power electronics by CHP system developers should be entitled to some type of financial relief from the utility or other entity to help offset the additional cost of these devices.*

***Recommendation #4**: The City of New York should work with Con Edison and the NYS Public Service Commission to examine how the 10/20 MW limits for interconnected DG might change if these limits were instead calculated as a percentage of peak demand, as is the practice commonly followed by other utilities. The results of this study should be used to select the method of calculating interconnected DG limits with the greatest potential for increasing levels of CHP deployment in New York City.*

***Recommendation #5**: The City of New York should work with the New York City Congressional delegation to advocate for an extension and possible expansion of the federal CHP business tax credit program.*

***Recommendation #6**: The NYC Economic Development Corporation and Department of Buildings should establish a mechanism to more systematically educate local developers of large new building projects about NYSERDA CHP-funding opportunities. EDC should also work with NYSERDA to develop funding programs specifically designed to support education and outreach programs targeting the local industrial sector and real estate developers and managers in New York City.*

***Recommendation #7**: The New York City Economic Development Corporation should work with NYSERDA and the New York State Department of Environmental Conservation to examine current emissions regulations to determine how the review process can more accurately account for the emissions benefits delivered by CHP.*

***Recommendation #8**: Once the Cogeneration Task Force has completed its work in resolving FDNY safety concerns with microturbines, the NYC Economic Development Corporation should collaborate with the NYC Department of Buildings to host a workshop educating building owners/managers and other key stakeholders on how the issue was resolved. This information should also be posted on the EDC website.*

***Recommendation #9**: The NYC Economic Development Corporation should seek the collaboration of a range of key local stakeholders in developing the specifications for an on-line portal tracking the status of CHP interconnection applications at Con Edison.*

Summary of Recommendations

Recommendation #10*: The NYC Economic Development Corporation should fund the development of a "DG Ombudsman" position responsible for helping to resolve CHP system installation problems in New York City.*

Recommendation #11: *The NYC Economic Development Corporation should meet with Con Edison to discuss their interconnection review staffing plans to ensure the utility is taking all steps necessary to support a potentially dramatic increase in interconnection applications.*

Recommendation #12*: If the City receives approval to establish its own independent financing mechanism for local energy projects, the New York City Economic Development Corporation should allocate a portion of the funds to supplement existing NYSERDA monies available for CHP viability assessment studies.*

Recommendation #13*: The NYC Economic Development Corporation should work with the Public Service Commission to examine the extent to which standby tariffs penalize CHP operations in New York City. As part of this analysis the City and State can examine ways to enhance the use of natural gas tariffs as an incentive for expanding CHP system use around the city.*

Appendix 1. Comparison of Key Characteristics of Various CHP Technologies[155]

	Steam Turbine	Reciprocating Engine	Combustion Turbine	Microturbine	Fuel Cell
Capacity (MW)	0.01-100	0.05-5	0.5-50	0.025-0.25	0.2-2
Footprint (ft^2/kW)	<0.1	0.22-0.31	0.02-0.61	0.15-1.5	0.6-4
Fuels	natural gas, diesel, fuel oil	natural gas, diesel, biodiesel, biogas	natural gas, biogas	natural gas, biogas	hydrogen, natural gas, biogas
$/kW	800-1000	800-1500	700-900	500-2500	>3000
Fuel conversion efficiency	5-15%	25-45%	25-40%	20-30%	40-70%
Thermal output (btu/kWh)	n/a	1,000-5,000	3,400-12,000	4,000-15,000	500-3,700
Heat temperature (°F)	n/a	200-500	500-1,100	400-650	140-700
Noise	high (requires building enclosure)	high (requires building enclosure)	moderate (enclosure with unit)	moderate (enclosure with unit)	low (no enclosure required)

[155] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002, pg. ES-2.

Appendix 2. Emissions Levels of Various CHP Technologies[156]

Type of Pollutant	Steam Turbine (lbs/MWh)	Reciprocating Engine (lbs/MWh)	Combustion Turbine (gas-fired)[157] (lbs/MWh)	Microturbine (lbs/MWh)	Fuel Cell (lbs/MWh)
NOx	Depends on boiler and fuel	1.48-44.3	1.08-2.43	0.4-2	0.03-0.06
CO	0.03-0.08	5.31-35.4	0.53-0.71	0.72-1.46	0.04-0.07
VOC	Depends on boiler	0.59-4.13	0.013-0.00041	<0.19	0.4-1
CO_2	Depends on boiler and fuel	1,051-1,338	1,411-1,887	1,529-1,928	890-1,135
SOx	Depends on fuel	Depends on fuel	Negligible	Negligible	Negligible

[156] NYSERDA, *CHP Market Potential for New York State (Final Report 02-12),* October 2002. pg. ES-2.
[157] VOC levels taken from EPA. *Compilation of Air Pollutant Emission Factors*, *AP-42, Fifth Edition, Volume I,* Chapter 3: "Stationary Internal Combustion Sources: Stationary Gas Turbines." April 2000. pg. 3.1-11 and 12. Accessed at http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf on July 31, 2007.

Appendix 3. Case Studies

Sheraton New York Hotel and Towers

Site Description: The Sheraton New York Hotel and Towers is a 1,750 room hotel and conference center located in midtown Manhattan. The hotel uses approximately 20 million kWh of electricity per year, and 80,000 Mlbs of steam for heating and domestic hot water needs.

Project Overview

Location:
New York, New York

Date of Installation:
2005

Facilities:
1,750 room hotel
43 meeting rooms
1.1 million square feet

Technology:
250-kW hydrogen fuel cell

Project Cost:
$1.84 million

Project Incentives:
$920,000 (NYSERDA)

Why the Sheraton decided to pursue a CHP system: In late 2002, John Lembo, Director of Energy for Starwood Hotels and Resorts, was approached by Steve Gabrielle of PPL Inc., a subsidiary of Pennsylvania Power and Light. Gabrielle presented an offer for Starwood's Edison Hotel property in New Jersey, whereby PPL would install a fuel cell CHP system on the property at no up-front cost to Starwood. The system would deliver electric power to the facility under a multi-year power purchase agreement (PPA) at a rate less than the local market price for electricity, and would also deliver free heat to the building. Starwood agreed to the Edison Hotel installation, as well as a second installation in Parsippany, New Jersey. After these successful deployments, a third Sheraton fuel cell installation was deployed at the Sheraton New York Hotel and Towers in 2005.

Technology Employed: Direct Fuel Cells (produced by FuelCell Energy of Danbury, Connecticut) are high-temperature, high-efficiency fuel cells that operate using natural gas. The 300A system deployed at the Sheraton New York Hotel and Towers generates 250kW of electricity, measures 10 feet by 28 feet and weighs 87,000 lbs. The fuel cells have a very good emissions profile, expelling an 'exhaust' of almost emission-free hot air. The fuel cell at the Sheraton New York Hotel and Towers offsets approximately 10% of the electrical usage and just under 4% of the thermal requirements of the facility.

Challenges: Given the cost of real estate, siting is one of the biggest obstacles for large-scale CHP installations in New York City. The size and heft of fuel cell technology makes it particularly difficult to site and move; the system must sit on a concrete slab or on a heavily-reinforced, elevated surface. The Sheraton New York Hotel and Towers had an unused setback on the roof of the 4^{th} floor of the building with steel dunnage already in place, making it an ideal location for the system. Since fuel cell systems are silent, no extraordinary measures were required to minimize noise. The installation was difficult, however, occurring at night and requiring the closure of the adjacent street.

Cost and Ownership Structure: As owner and operator of the fuel cell technology, PPL financed the Sheraton New York Hotel and Towers project at a cost of $1.84 million. PPL was able to take advantage of incentives offered by NYSERDA amounting to $920,000 – approximately half of the total project costs. The PPA agreement guarantees the hotel that power delivered by the fuel cell will be charged at a rate 5% less than the tariff charged for the balance of the hotel's power. Because the system also delivers free hot water to the hotel, the Sheraton's annual energy charges are expected to decrease by $170,000 a year.

Weill Cornell Medical Center (part of New York-Presbyterian Hospital)

Site Description: Located on the Upper East Side, the New York-Presbyterian Hospital Weill Cornell Medical Center is a 2,369-bed academic medical center with extensive inpatient, ambulatory, and preventive care facilities.

Why NYPH decided to pursue a CHP system: Rising energy costs led New York-Presbyterian Hospital (NYPH) to develop and implement a variety of energy management and conservation measures. According to Jennifer Kearney, Director of Energy Programs at the hospital, cogeneration was identified as the single greatest opportunity for NYPH to reduce utility costs. In 2004, NYPH completed a study of cogeneration feasibility, funded by NYSERDA. Once completed, the study was subject to a rigorous peer review by a second engineering team. Upon completion of the peer review, an additional "Fatal Flaw" analysis was performed to ensure the viability of the project vis-à-vis concerns such as ConEdison interconnection, environmental permitting, economic sensitivity, structural requirements, construction cost estimates, and the development of a long-term service agreement.

Technology deployed: A 7.5MW Power Train gas turbine and heat-recovery steam generator will be deployed at the Weill Cornell Medical Center campus in April 2008. The systems have a 20 year lifespan, but require re-coring every 5 years. This system is expected to meet approximately 50% of the facility's peak load, and will be located in an existing boiler plant.

Project Overview

Location:
New York, New York

Date of Installation:
April 2008

Facilities:
2,369-bed medical center

Technology:
7.5 MW gas turbine

Project Cost:
$22 million

Project Incentives:
$1 million (NYSERDA)

Challenges: NYPH would like to install a larger CHP system with increased generating capacity, but due to space and siting constraints, the 7.5MW system is the largest system they can accommodate.

NYPH requested permission to tap into a nearby high-pressure gas line from Con Edison in order to access the high pressure gas their CHP system requires. However, NYPH was unable to secure access to the gas line, forcing the hospital to spend an additional $600,000 on a gas compressor to boost pressure levels.

Cost and Ownership Structure: As owner and operator of their CHP installation, NYPH is financing the $23 million CHP project on its own. NYPH has taken advantage of several incentives offered by NYSERDA that collectively total nearly $1 million. Once the CHP system is operational, they anticipate energy cost savings of $5 million annually.

Colonial Glass & Mirror

Site Description: Colonial Glass & Mirror is a glass and mirror manufacturing business located in Brooklyn. Daily operation at Colonial Glass & Mirror relies on the seamless functioning of multiple energy-intensive technologies, including glass fabricating machines, tempering ovens, and glass washing systems.

Why Colonial Glass & Mirror decided to pursue a CHP System: Zachary Weiner, President of Colonial Glass & Mirror, wanted to take advantage of two incentive programs offered by the City of New York: the Industrial and Commercial Incentive Program (ICIP) offered by the New York City Economic Development Corporation, and the Energy Cost Savings Program. In order to participate in these two programs, Weiner learned he would have to invest in capital improvements to his business facilities. In the late 1990s, Weiner investigated CHP systems as part of his capital improvements, and discovered that investing in a CHP system would cut his electrical costs by nearly two-thirds. In 1999, Weiner proceeded with the first CHP installation, and deployed a second CHP system in 2006.

Technology Employed: In 1999, Weiner installed a Mitsubishi dual-fuel (diesel and natural gas) engine that generates 800kW and 2,400,000 Btu of thermal power. Seven years later, Weiner installed a second gas-powered CHP system that generates 1,000kW. The 1,000kW generator now meets the energy needs of the entire operation, replacing the Mitsubishi system, which is now used solely as a backup. The CHP system is shut down at night when manufacturing operations cease, with Colonial Glass relying on Con Edison's grid to power necessary lighting and an alarm system.

Challenges: The new 1,000kW generator shuts down about 5 times a year for minor maintenance. Colonial Glass does not have a single person dedicated to maintaining the system; instead, maintenance and operation of the system is part of the maintenance crew's general responsibilities. Neighborhood noise complaints are the most significant issue facing the operation of this system.

Cost and Ownership Structure: Colonial Glass and Mirror is the owner and operator of both its CHP installations. The 800kW system cost $500,000 to purchase and install, and Weiner reports that it paid for itself in two years. The 1,000kW system cost $1 million; after incentives, Weiner reports a savings of $400,000 a year with this system.

Project Overview

Location:
Brooklyn, New York

Date of Installations:
1st installation: 1999
2nd installation: 2006

Facilities:
43,000 sq. ft. manufacturing plant

Technology:
1st installation: 800kW, 2,400,000 Btu

2nd installation: 1,000kW

Total installed capacity: 1,800 kW

Project Cost:
Total cost: $1.5 million

$500,000 for 800kW CHP system

$1 million for 1,000kW CHP system

Project Incentives:
Savings of $200,000 a year with 800 kW CHP system

Savings of $400,000 a year with 1,000 kW CHP system

Clinton Hill Apartments

Project Overview
Location: Brooklyn, New York
Date of Installation: 2006
Facilities: 2-acre campus 12 apartment buildings 1,221 apartments
Technology: Capstone C60 & C30 microturbine generators
Total installed capacity: 600kW
Project Cost: $1.9 million
Project Incentives: Total Incentives to date: approx $1.4 million (Various sources)

Site Description: The Clinton Hill Apartments complex sits on a 2-acre campus, consisting of twelve apartment buildings with a total of 1,221 apartments. Approximately 700 residents live in the complex.

Why Clinton Hill Apartments decided to pursue a CHP system: In 2001, David Ahrens of Energy Spectrum Inc. approached the Clinton Hill Apartment Owners Corporation (CHAOC) with a proposal for a microturbine CHP system, after learning that the apartments were due for an electrical system upgrade. Though CHAOC was hesitant at first to pursue the project, the city-wide blackout of August 2003 convinced residents of the value of reliable on-site power. After CHAOC decided to proceed with the project, Ahrens obtained funding from NYSERDA and the U.S. Department of Energy to conduct a six-month feasibility study. As a result of this study, it was determined that two microturbines would be deployed per building, one with a generating capacity of 60kW and the other with a capacity of 30kW. The exhaust heat from the systems would replace three high-NOx yielding 400–horsepower boilers that supplied residents' hot water. The 60kW system would be baseloaded, and the second microturbine would be used to meet the daily energy demand peaks, with Con Ed power being drawn on as needed.

Technology Employed: Capstone Turbine's C30 and C60 microturbines are compact, low-emission generators that operate on natural gas. Seven C60s and six C30s are deployed at the Clinton Hill Apartments; their combined capacity equals 600kW of electric power and the entire complex's thermal load. The generators are roughly the size of a large refrigerator, weighing in at 1671 and 891 lbs. respectively. Should the Con Ed grid go down, batteries will power up the generator, allowing elevators and essential lighting systems to remain operational. The C60s will run at maximum capacity year-round, while Ahrens estimates that the smaller turbines will run 50%–60% of the time in winter and 70%–80% of the time in summer.

Challenges: The co-op was initially reluctant to embrace the proposal, due to noise level concerns. However, after a microturbine site visit in Long Island, John Dew, President of CHAOC reported, "When I walked up to it, I didn't even know it was on. It was that quiet."

In order to install the microturbines, a high-pressure gas feed needed to be extended from a gas main located hundreds of yards away. Negotiations with the local gas utility, Keyspan Energy, continued for months before a favorable ruling was received that allowed the new tap to be dug.

Cost and Ownership Structure: Clinton Hill residents are the owners of the microturbines. The co-op has contracted for five years of maintenance service from UTC Power and Carrier, at a cost ranging from 1.8 to 2.2 cents per kWh of production. The total budget of the project amounted to $1.9 million, but Clinton Hill was able to secure grants and incentives to cover most of the project cost: $758,500 in NYSERDA grants, a gift from Clean Air Communities (CAC) amounting to $400,000, a New York ISO grant of $54,000, and a city property tax reduction for the installation of capital equipment amounting to $180,000 (allocated over 12 years). NYSERDA estimates that the project will save Clinton Hill Apartments $217,000 annually in energy costs.

Equity Office – 717 5th Avenue

Project Overview
Location: New York, New York
Date of Installation: 2005
Facilities: 26 story, 450,000 sq. ft. Class-A commercial building
Technology: Two Northern Power 800 kW lean-burn reciprocating engines
Total installed capacity: 1600kW
Project Cost: $4.1 million
Project Incentives: $745,000 (NYSERDA)

Site Description: The 450,000-square foot, Class-A office building is managed, owned and leased by Equity Office, the nation's largest office building owner and manager. The building has a 15-story low-rise portion and a 26-story tower, with a peak electrical demand of 1,800 kW in the winter and 2,100 kW in the summer.

Why Equity Office decided to pursue a CHP system: The idea of installing a CHP system at 717 5th Avenue originated with the previous owners of the building. However, the CHP system was not installed until after the building was sold to Equity Office. Seeking greater system reliability and lower energy costs, Equity Office approached Northern Power (now Distributed Energy Systems) to provide engineering, procurement and construction of the CHP system.

Technology deployed: Northern Power installed two Caterpillar 800kW lean burn, reciprocating engine generators on the 15th Floor of 717 5th Avenue. Together the two engines produce approximately 1600kW of electricity, meeting approximately 60% of the building's electric usage and 65% of its cooling and heating needs. The technology is synchronously interconnected to Con Edison's grid, which means that whenever the CHP system is operational, the building remains connected to Con Edison, running in parallel operation with their grid. The system is primarily designed to operate to cut peak load during daytime working hours, so it shuts down at 6 PM each day. Because of its synchronous generation design, the system is capable of operating in standalone (island) mode in the event of a grid blackout.

Challenges: As the first synchronous generator to be interconnected to the congested midtown grid, Northern Power worked closely with Con Edison to ensure that the local grid would not be adversely affected by the generators at 717 5th Avenue in the event of a power outage. The project benefited from the fact that the Equity Office building is fed by a substation recently upgraded by Con Edison, which is now capable of withstanding additional fault current from a synchronous generator without the need for a fault current limiter or similar device.

Siting the system also posed considerable challenges. An entire city block in midtown Manhattan had to be closed down while a 600-ton crane placed the system on top of the building's lower roof. In order to minimize operational noise, the system had to be contained within a sound-attenuated housing enclosure and mounted on steel dunnage that uses vibration isolators to reduce noise.

Project Cost and Ownership Structure: Equity Office owns the CHP system, while Distributed Energy Systems is under contract to provide full maintenance for the installation. The total project cost amounted to $4.1 million and NYSERDA estimates that this project will result in over $500,000 in annual net energy savings.

Appendix 4. Micro-CHP: Coming to a home near you?

Market and Technology

Micro-CHP is a relatively new technology that provides micro-scale on-site heat and power generation. As the name implies, these systems are far smaller than CHP units designed for industrial firms or large buildings. Micro-CHP is equally efficient and clean as larger CHP units, but the technology is so small that it can be installed under a kitchen counter or in a small basement or garage. Micro-CHP units are easy to operate and fairly quiet.

Like bigger CHP systems, there are a variety of micro-CHP technologies, including internal combustion engines, sterling engines, rankine cycle engines and fuel cells. The average micro-CHP unit generates 3-7 kW of heat and 1-5 kW of power, sufficient to provide 100% of an average home's heat needs and between 30% and 50% of its power needs. Systems can operate 3,000-6,000 hours, or 1/3-2/3 of the year without maintenance.

Currently, the leading manufacturers of micro-CHP systems are Whisper Tech and Honda. Whisper Tech makes a small unit of the size of a dishwasher based on a stirling external combustion engine that is quiet enough to be installed in the kitchen. E.ON UK estimates that 80,000 of these units will be deployed in the UK by 2008. Honda's *Ecowill*^{tm} device is growing in popularity in Japan, and its *freewatt*^{tm} system is currently being deployed on a commercial basis in the US.

Growing Demand for Micro-CHP in Japan and the UK

Ecowill^{tm}, a 1 kW micro-CHP unit manufactured by Honda, is quite popular in Japan. Since its entry into the market in 2003, almost 50,000 units have been installed. The *Ecowill*^{tm} system consists of two basic parts: an engine and a furnace. During warmer months, the heat output of the engine is sufficient to meet the thermal needs of the house. In winter, when heating demand peaks, the engine's heat output is supplemented by the furnace. *Ecowill*^{tm} is distributed by large utilities such as Tokyo and Osaka Gas. Depending on the configuration selected, an installed system costs approximately $6,300-$7,300; this price has remained constant since the systems were first introduced four years ago. At this price point, the estimated payback period is approximately five years.[158] According to Honda Japan, the Japanese government supports the deployment of micro-CHP systems by providing a subsidy of approximately $1,400 per unit, or approximately 20% of the technology cost.[159]

Whispergen micro-CHP unit

E.ON UK will begin mass production of *WhisperGen*^{tm} units by the end of 2007. The *WhisperGen*^{tm} system generates 1 kW of power and 7 kW of heat. According to E.ON UK staff, no decision has yet been made on how to price the system, but the expectation is that the price for a 1kW electrical unit will probably be around £600 to £1000 more than a new condensing boiler, giving the system a 3-4 year payback period.[160] Homeowners in the UK will be allowed to export excess electricity back to the grid, and E.OK is currently assessing a number of alternatives to offer export terms to customers. At the moment the company offers to buy surplus power for approximately 5 pence/kWh, but this value may increase. The company is also examining the

[158] Communication with Teruki Hatano, Manager of North American Division, Honda Japan. April 26, 2007.
[159] Ibid.
[160] Communication with Simon Schmitz, Senior Strategy Analyst, Technology Commercialization Unit, Retail Strategy, E.ON UK. April 2, 2007.

possibility of operating these systems remotely via computer, creating a virtual power plant that is dispatchable on command.

Micro-CHP in the US – First Steps

The first micro-CHP system tested in the US was the Aisin Seiki G60. This $16,000 unit relied on an internal combustion engine, generating 5.4 kW of power at a cost between $0.15 and $0.18 per kWh. One of the testing sites was at Consumers Energy, a small energy delivery and management co-op in Iowa. According to Brian Heithoff, CEO of Consumers Energy, the cost of the technology was found to be too high for the product to be marketable in the US.[161]


Honda FreeWatt micro-CHP system

Honda's *freewatt*[tm] system is especially designed for the US household market. *freewatt*[tm] relies on an internal combustion engine capable of producing 3.2 kW of heat and 1.2 kW of power. According to Climate Energy LLC, a Massachusetts-based micro-CHP development and marketing company, the unit covers almost 100% of a home's heat needs and up to 50% of its power needs, based on the average US home's annual electricity consumption of 8,000-10,000 kWh.[162] Because of its larger size, the system must generally be installed in a garage or basement. Like its technological cousin *Ecowill*[tm], the *freewatt*[tm] system consists of an engine and a boiler. Similar to the *WhisperGen*[tm] system, *Ecowill*[tm] also has a controller unit that can be connected to the internet for remote monitoring and maintenance. Home-owners can see their energy consumption and even control it when they are away via the internet. After 5,500 hours of operation, the unit will automatically notify the service company that it requires service, triggering a maintenance call. Maintenance is relatively easy, requiring the system to be shut down for one hour to change the oil and spark plugs and service the boiler. If allowed by the local utility, the system can also be set up to provide dispatchable power back into the grid.

freewatt[tm]'s biggest downside is its cost: including equipment, installation and a 3-year service contract, the price is $13,500, although subsidies may be available to reduce this cost in certain states.[163] This rate is significantly higher than a new high-efficiency heating furnace running approximately $5,500. According to Climate Energy, the firm responsible for the distribution of this technology in the US, "the early adopter [of *freewatt*[tm]] is someone who wants to have a green, high-tech gadget in her basement."[164] *freewatt*[tm] is currently being marketed in the northeastern US, where demand for heat is high and net metering laws allow households deploying the systems to sell their electricity back to the grid.

Micro-CHP in New York?

It is simply a matter of time before micro-CHP becomes an economically viable technology in New York City, where it has the potential to revolutionize the local energy marketplace by bringing small-scale CHP into homes and individual apartments. In the event of a demand spike for micro-CHP systems, one can expect that Con Edison will face major administrative and

[161] Communication with Brian Heithoff, CEO, Consumers Energy. March 20, 2007.
[162] Communication with Mark Macaulay, Director of Mechanical Engineering, Climate Energy. April 12, 2007.
[163] For the Keyspan Energy Delivery Program that offers incentives to energy-efficient installations, see Database of State Incentives for Renewables and Efficiency at http://www.dsireusa.org/.
[164] Communication with Mark Macaulay, Director of Mechanical Engineering, Climate Energy. April 19, 2007.

technical difficulties posed by a sharp increase in the number of systems to be interconnected. This would likely include lengthy wait times for interconnection approvals. To the extent that micro-CHP systems do not contribute a massive amount of fault current to the system, interconnection may not be a problem. More information is needed on the potential fault current contribution of micro-CHP, as well as whether fault current mitigation technologies are necessary and/or are already incorporated into the units themselves.

Officials at companies pursuing the deployment of micro-CHP in other states recommend that the City of New York and Con Edison begin planning now about how micro-CHP could be integrated into the city's energy supply system. This would include exploring any interconnection and fault current issues posed by micro-CHP, as well as determining how to address the potential administrative burden of increased interconnection applications.

Appendix 5. List of Current CHP-Related Program Opportunity Notices from NYSERDA[165]

Program Opportunity Notice (PON) Number	Title	Application Deadline	Description
None	Flexible Technical Assistance (FlexTech)	None (Continuous)	Provides costsharing on technical assistance services tailored to answer customer-specific energy questions. Services are performed by pre-qualified FlexTech Consultants.
PON 941	New York Energy \$mart[SM] Loan Fund	8/31/2007	Seeks 1) applications from potential borrowers for interest rate reductions on Loans and Leases from Participating Lenders and Lessors for energy efficiency improvements, new construction energy measures, and renewable technologies; and 2) participation agreements from potential participating Lenders or Lessors who wish to offer the **New York Energy \$martSM** Loan Fund (Loan Fund) to their customers.
PON 1047	Technical Assistance	11/30/2007	Provides cost-sharing for studies which identify and encourage the implementation of cost-effective improvements for energy efficiency, peak load, commercially available combined heat and power (CHP), and renewable generation projects.
PON 1101	Enhanced Commercial/Industrial Performance Program	3/31/08	Provides performance-based incentives and prescriptive incentives for energy efficiency upgrades in existing buildings.

[165] NYSERDA. Funding Opportunities (website). Accessed at http://www.nyserda.org/Funding/default.asp on July 31, 2007. PON recommendations provided in telephone interview with Mark Gundrum, Project Manager, NYSERDA. July 31, 2007.

Appendix 6. Database of Small-Scale CHP Installations in New York City

Technology Legend		**Fuel Legend**	
ERENG:	Reciprocating Engine	NG:	Natural Gas
FCEL :	Fuel Cell	BIOMASS :	Biomass, including biogas
MT:	Microturbine	OIL:	Oil
CT:	Combustion Turbine	OTR:	Other
B/ST:	Boiler/Steam Turbine		

Organization Name	Facility Name	Borough	Application	Year	Tech	Cap (kW)	Fuel
South Bronx Community Management Company	OUB Houses Housing Company, Inc.	Bronx	Apartments	1989	ERENG	120	NG
New York Wildlife Conservation Society	Bronx Zoo	Bronx	Museums/Zoos	1991	ERENG	3,600	NG
Flex O Tex	Flex O Tex Laundry	Bronx	Laundries	1998	ERENG	500	NG
CRM Inc.	Bronx Center for Rehabilitation	Bronx	Hospitals/Healthcare	2001	ERENG	150	NG
All Systems Cogeneration	Manhattanville Nursing Center	Bronx	Nursing Homes	2003	ERENG	120	NG
Hermany Farms	Hermany Farms	Bronx	Food Processing	2003	ERENG	225	NG
N.Y.C. Dept. Of Environmental Protection	Hunts Point WPCP	Bronx	Wastewater Treatment	2003	FCEL	600	BIO-MASS
Hazel Towers	Hazel Towers	Bronx	Apartments	2004	ERENG	120	NG
Grand Manor Nursing and Rehab	Grand Manor Nursing and Rehab	Bronx	Nursing Homes	2005	ERENG	150	NG
Home Depot	Home Depot - Baychester	Bronx	General Merch. Stores	2005	ERENG	750	NG
Jewish Home and Hospital	Jewish Home and Hospital	Bronx	Hospitals/Healthcare	2005	ERENG	400	NG
Kings Harbor Multicare Center	Kings Harbor Multicare Center	Bronx	Nursing Homes	2005	ERENG	150	NG
Unknown	Apartments	Bronx	Apartments	2006	ERENG	75	NG
Aegis Energy Services Inc.	Aegis Energy Services Inc.	Bronx	Nursing Homes	.	ERENG	300	NG
New York Wildlife Conservation Society	Bronx Zoo	Bronx	Museums/Zoos		FCEL	200	NG
Glenmore Plastics	Glenmore Plastics Facility	Brooklyn	Chemicals	1977	ERENG	500	NG
Magnolia Industries	Magnolia Industries	Brooklyn	Rubber/Plastics	1979	ERENG	1,160	NG
Admiral Plastics	Admiral Plastics	Brooklyn	Rubber/Plastics	1980	ERENG	2,350	NG
Keyspan Energy Corp	Brooklyn Union Gas Company	Brooklyn	Utilities	1986	ERENG	60	NG
New York Telephone	New York Telephone	Brooklyn	Communications	1986	ERENG	3,250	NG
N.Y.C. Dept. Of Environmental Protection	Coney Island WPCP	Brooklyn	Wastewater Treatment	1987	ERENG	6,400	NG
Oceangate Associates	29th Street	Brooklyn	Apartments	1987	ERENG	60	NG
Oceangate Associates	24th Street	Brooklyn	Apartments	1987	ERENG	60	NG
Surf 21 Associates	Surf 21 Associates	Brooklyn	Apartments	1987	ERENG	60	NG
Bay Park Associates	Bay Park 1 Associates	Brooklyn	Apartments	1988	ERENG	145	NG

Bay Park Associates	Bay Park 2	Brooklyn	Apartments	1988	ERENG	145	NG
International Cogeneration Corporation	YMCA Of Greater NY-Prospect Park	Brooklyn	Amusement/Recreation	1988	ERENG	75	NG
Linden Plaza Associates	Linden Plaza Apartments	Brooklyn	Apartments	1990	ERENG	150	NG
New York Methodist Hospital	Methodist Hospital	Brooklyn	Hospitals/Healthcare	1990	ERENG	3,760	NG
American DG/AES New Jersey Cogen	Aishel Avraham Nursing Home	Brooklyn	Nursing Homes	1991	ERENG	75	NG
Cogen Power Company, Inc.	Paeizdegat Boat & Raquet Club	Brooklyn	Amusement/Recreation	1991	ERENG	600	OIL
Cogeneration Power Company, Inc.	Rjr Health & Swim Club	Brooklyn	Amusement/Recreation	1991	ERENG	600	OIL
Kingsbrook Jewish Medical Center	Kingsbrook Jewish Medical Center	Brooklyn	Hospitals/Healthcare	1991	ERENG	500	NG
N.Y.C. Dept. Of Environmental Protection	Owl's Head Plant	Brooklyn	Wastewater Treatment	1991	ERENG	6,000	NG
Chromium Plating & Polishing Corporation	Chromium Plating Plant	Brooklyn	Fabricated Metals	1993	ERENG	525	NG
Epner Technology	25 Division Place Project	Brooklyn	Misc. Services	1993	ERENG	200	NG
Golten's Marine Co. Inc.	Golten's Marine Facility	Brooklyn	Transportation Equip.	1993	ERENG	100	NG
Lutheran Medical Center	Lutheran Medical Center Hospital	Brooklyn	Hospitals/Healthcare	1993	ERENG	1,600	NG
St. Mary's Hospital	St. Mary's Hospital	Brooklyn	Hospitals/Healthcare	1994	ERENG	1,200	NG
Private Brands	50 Wallabout Street Project	Brooklyn	Food Processing	1995	ERENG	545	NG
Superior Fiber Mills, Inc.	Superior Fiber Mills, Inc.	Brooklyn	Textiles	1999	ERENG	250	NG
Lucky Mcmxcvi, L.L.C.	Lucky Mcmxcvi, L.L.C.	Brooklyn	Unknown	2000	ERENG	1,420	NG
United States Of America	Louis Food Service	Brooklyn	Food Processing	2000	ERENG	194	NG
New York Wildlife Conservation Society	New York Aquarium	Brooklyn	Museums/Zoos	2001	FCEL	200	NG
All Systems Cogeneration	Seacrest Healthcare Facility	Brooklyn	Nursing Homes	2003	ERENG	120	NG
Arrow Linen Supply Co.	Arrow Linen Supply Co.	Brooklyn	Laundries	2003	ERENG	360	NG
Greenpark Care Center	Greenpark Care Center	Brooklyn	Nursing Homes	2003	ERENG	150	NG
NYSERDA	SeaRise I & II Apartments	Brooklyn	Apartments	2003	ERENG	220	NG
N.Y.C. Dept. Of Environmental Protection	26th Ward WPCP	Brooklyn	Wastewater Treatment	2003	FCEL	400	BIO-MASS
N.Y.C. Dept. Of Environmental Protection	Red Hook WPCP	Brooklyn	Wastewater Treatment	2003	FCEL	400	BIO-MASS
4C Foods	4C Foods	Brooklyn	Food Processing	2004	ERENG	435	NG
Grenadier Reality / 3325 Neptune Ave	3225 Neptune Ave	Brooklyn	Apartments	2004	ERENG	120	NG
Grenadier Reality / 3405 Neptune Ave	3405 Neptune Ave	Brooklyn	Apartments	2004	ERENG	120	NG
Paradise Plastics	Paradise Plastics	Brooklyn	Chemicals	2004	ERENG	510	NG
Shore View Nursing Home	Shore View Nursing Home	Brooklyn	Hospitals/Healthcare	2004	ERENG	80	NG
City Facility	City Facility	Brooklyn	General Gov't	2004	MT	120	NG

Alpha Plastics	Alpha Plastics	Brooklyn	Rubber/Plastics	2005	MT	180	NG
Floyd Bennett Field	Floyd Bennett Field	Brooklyn	Air Transportation	2005	MT	180	NG
Nursing Home	Nursing Home	Brooklyn	Nursing Homes	2006	ERENG	75	NG
ShopRite Supermarket	Shop Rite Supermarket	Brooklyn	Food Stores	2006	ERENG	140	NG
Clinton Hill Apartments	Clinton Hill Apartments	Brooklyn	Apartments	2006	MT	540	NG
Macy's East	Macy's East	Brooklyn	General Merch. Stores		ERENG	750	NG
Tishman Building	11 West 42nd Street Building	Manhattan	Office Buildings	1980	ERENG	5,400	OIL
New York University	Campus Cogeneration Plant	Manhattan	Colleges/Univ.	1984	B/ST	6,000	OIL
International Cogeneration Corporation	West Side YMCA	Manhattan	Amusement/Recreati on	1988	ERENG	225	NG
Rockefeller University	University Boiler House	Manhattan	Colleges/Univ.	1991	CT	800	OIL
St. Lukes/Roosevelt Hospital Center	St. Lukes/ Roosevelt Hospital Center	Manhattan	Hospitals/Healthcare	1993	B/ST	150	OTR
Four Times Square Associates, LLC	Conde Nast Building - Times Square	Manhattan	Office Buildings	1999	FCEL	400	NG
Unknown	125 116th Food Corp	Manhattan	Food Processing	2000	ERENG	420	NG
New Yorker Hotel	New Yorker Hotel	Manhattan	Hotels	2001	ERENG	600	NG
Hudson Hotel	Hudson Hotel	Manhattan	Hotels	2003	ERENG	300	NG
NYSERDA	Compudye	Manhattan	Chemicals	2003	ERENG	900	NG
CRM Inc.	205 West End Condo	Manhattan	Apartments	2004	ERENG	300	NG
CRM Inc.	25 Tudor City	Manhattan	Apartments	2004	ERENG	150	NG
Equity Office Properties / 717 5th Avenue	717 5th Avenue	Manhattan	Office Buildings	2004	ERENG	1,600	NG
Tudor Realty (25 Tudor City Place)	Tudor Realty (25 Tudor City Place)	Manhattan	Apartments	2004	ERENG	150	NG
DSM Energy	10 West 66th St	Manhattan	Apartments	2004	MT	70	NG
NYSERDA	160 West End Avenue Condominium	Manhattan	Apartments	2004	MT	300	NG
Northern Power Systems	Synchronous Gens ConEd	Manhattan	Utilities	2005	ERENG	1,600	NG
Tudor Gardens	2 Tudor City Place	Manhattan	Apartments	2005	ERENG	150	NG
Starwood Hotels	Sheraton New York	Manhattan	Hotels	2005	FCEL	250	NG
Tribeca Green	Tribeca Green	Manhattan	Apartments	2005	MT	60	NG
Grand Central Station	Grand Central Station	Manhattan	General Gov't	2006	FCEL	400	NG
Stevenson Commons	Stevenson Commons	Manhattan	Apartments	2006	MT	70	NG
New York Presbyterian Hospital	New York Presbyterian Hospital	Manhattan	Hospitals/Healthcare		CT	7,500	NG
New York Times Company	New York Times Company	Manhattan	Office Buildings		ERENG	1,400	NG
Rachel Bridge Corp.	Rachel Bridge	Manhattan	Apartments		ERENG	1750	NG
Redwood Power Company	Redwood Power Company	Manhattan	Office Buildings		ERENG	4000	NG
New York Racquet & Tennis Club	New York Racquet & Tennis Club	Manhattan	Amusement/Recreati on		MT	100	NG

New York Racquet & Tennis Club	New York Racquet & Tennis Club	Manhattan	Amusement/Recreation		MT	100	NG
Schwab House	Schwab House	Manhattan	Apartments		MT	280	NG
230 Park Avenue	230 Park Avenue	Manhattan	Office Buildings		CT	960	NG
Reckson Associates Office Building	Reckson Associates Office Building	Manhattan	Office Buildings		CT	3000	NG
Honeywell Farms, Inc.	Honeywell Farms, Inc.	Queens	Food Processing	1974	ERENG	4,400	NG
Three Towers Asssociates	North Shore Towers	Queens	Apartments	1974	ERENG	7,500	NG
Fink Baking Corporation	Fink Baking Corporation	Queens	Food Processing	1980	ERENG	1,900	OIL
National Urban Energy Corporation	Big Six Towers	Queens	Apartments	1980	ERENG	4,050	NG
Cogenic Energy Systems, Inc.	Holiday Inn-La Guardia	Queens	Hotels	1984	ERENG	100	NG
Cogenic Energy Systems, Inc.	Uniforms For Industry, Inc.	Queens	Laundries	1984	ERENG	500	NG
Four Star Dairy	Four Star Dairy	Queens	Agriculture	1987	ERENG	595	OIL
Keyspan Energy Corp	JFK International Airport	Queens	Air Transportation	1988	ERENG	75	NG
Utility Systems Corporation /Cogenic	Continental Baking Company	Queens	Food Processing	1988	ERENG	500	NG
American DG/AES New Jersey Cogen	Resort Nursing Home	Queens	Nursing Homes	1989	ERENG	60	NG
American DG/AES New Jersey Cogen	Park Nursing Home	Queens	Nursing Homes	1989	ERENG	60	NG
American DG/AES New Jersey Cogen	Rockaway Care Center	Queens	Nursing Homes	1989	ERENG	120	NG
Rockaway One	Wavecrest Gardens	Queens	Apartments	1989	ERENG	60	NG
St. John's University (Cogen Financial)	St. John's University	Queens	Colleges/Univ.	1989	ERENG	225	OIL
Synergics, Inc.	Resort Health Related Facility	Queens	Nursing Homes	1989	ERENG	120	NG
Aguilar Gardens, Inc.	Aguilar Gardens Apartments	Queens	Apartments	1990	ERENG	100	NG
BEI Energy Corporation	BQE Health Club	Queens	Amusement/Recreation	1990	ERENG	72	NG
ICC Technologies, Inc.	First National Supermarket-Glendale	Queens	Food Stores	1990	ERENG	150	NG
EUA/FRCII Energy Associates	Park Nursing	Queens	Nursing Homes	1993	ERENG	60	NG
EUA/FRCII Energy Associates	Rockaway Care Center	Queens	Nursing Homes	1993	ERENG	150	NG
Haven Manor Health Facility	Haven Manor Health Facility	Queens	Nursing Homes	2000	ERENG	60	NG
J&J Farms Creamery	J&J Farms Creamery Facility	Queens	Food Processing	2000	ERENG	375	NG
CRM Inc.	Berkeley Cooperative Towers	Queens	Apartments	2001	ERENG	300	NG
Atlantis Marine World Aquarium	Atlantis Marine World Aquarium	Queens	Amusement/Recreation	2001	MT	30	NG
American DG	Holliswood Care Center	Queens	Nursing Homes	2003	ERENG	150	NG
LaGuardia Corporation	Bulova Office	Queens	Office Buildings	2003	ERENG	500	NG

Rego Park Nursing Home	Rego Park Nursing Home	Queens	Nursing Homes	2003	ERENG	75	NG
Ozanam Hall of Queens Nursing Home	Ozanam Hall of Queens Nursing Home	Queens	Nursing Homes	2004	MT	600	NG
Home Depot	Home Depot - Ozone Park	Queens	General Merch. Stores	2005	ERENG	750	NG
Home Depot	Home Depot - Woodhaven	Queens	General Merch. Stores	2005	ERENG	750	NG
Parman Corporation	Cogen Parker Towers	Queens	Office Buildings	2005	ERENG	1,200	NG
Nursing Home	Nursing Home	Queens	Nursing Homes	2006	ERENG	225	NG
ConEdison	Learning Center at ConEdison	Queens	Office Buildings		MT	70	NG
Sun Chemical Corporation	Sun Oil Corporation	Staten Island	Chemicals	1982	ERENG	75	NG
Brooklyn Union Gas Company/GRI	Staten Island Hospital	Staten Island	Hospitals/Healthcare	1988	ERENG	22	NG
Community Health Sys Of Staten Island	Staten Island Univ Hospital South	Staten Island	Hospitals/Healthcare	1992	ERENG	1,200	NG
Sun Chemical Corporation	Fuel Cell Cogeneration Project	Staten Island	Chemicals	1996	FCEL	400	NG
Staten Island University Hospital	Staten Island University Hospital	Staten Island	Hospitals/Healthcare	1997	ERENG	4,475	NG
Vanbro Asphalt	Vanbro Asphalt	Staten Island	Stone/Clay/Glass	1999	ERENG	1,250	NG
CRM Inc.	Golden Gate Rehab Center	Staten Island	Hospitals/Healthcare	2003	ERENG	150	NG
N.Y.C. Dept. Of Environmental Protection	Oakwood Beach WPCP	Staten Island	Wastewater Treatment	2003	FCEL	200	BIO-MASS
Home Depot	Home Depot - Staten Island	Staten Island	General Merch. Stores	2005	ERENG	750	NG